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FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA,

FOR THE

PROMOTION OF THE MECHANIC ARTS.

VOL. LV.] FEBRUARY, 1868. [No. 2.

EDITORIAL.

ITEMS AND NOVELTIES.

Electric Car Starter, invented and patented by John and William H. Clark.—The present plan of regulating the time at which the various city cars on any route leave the depot or station, is to employ a man whose duty it is to notify the various conductors. Besides the expense involved in this arrangement, there are various other objections which have shown themselves in practice. Thus, a little delay or irregularity inseparable from human agency; a little favoritism, or at least a suspicion of such, trifling in themselves, occasion disputes, and greater irregularities in the running, by which the service of the companies and of the public suffers detriment.

The apparatus named above, a working model of which was exhibited at the last meeting of the Institute, obviates the various difficulties mentioned.

It consists of an attachment to a clock, which may be placed in

the superintendent's office, which will cause a bell to be rung at certain intervals, at any convenient point, near or distant. The length of interval between ringing may be changed at any time, in a moment, without in any way disturbing the action of the apparatus, or affecting the time of the regulating clock. It would be impossible, without several drawings, to give a correct idea of the mechanical details involved; but we may state that they are well arranged, efficient, and durable.

Lead Manufacture in San Francisco.—Extensive works are under way in the above place for the manufacture of lead on a large scale. The supply of ores is very abundant, and generally sufficient silver is found contained in it to pay for transportation and working.

A Constant Battery.—Boettzer has constructed a galvanic battery of such constancy that it retains its activity for several years, and is admirably adapted to the working of electric clocks, ringing electric bells, and the requirements of electro-metallurgy.

Each cell consists of a cylinder of thick plate zinc, enclosed in a glass jar. In the centre of the cylinder is placed a bar of compact coke, and the intervening space is packed with a powder composed of a mixture of equal volumes of pounded sulphate of magnesia and common salt, moistened with a saturated solution of these two substances. The salt mixture is moistened from time to time.—*Artizan.*

The Mont Cenis Tunnel advanced 109 metres, or 357 feet, during November.

The American Tube Well, of which we gave a brief account in our December number, increases in favor not only in England, where it has been lately introduced, but in France also. Its peculiar merits consist not only in its cheapness, but in its entire freedom from surface drainage, and when water is reached, if it should not prove sweet, the tube may be sunk beneath that bed until pure water is obtained.

Gold Yield.—The yield of gold in this country for the past year amounted to $74,000,000.

Liebig's Extract of Meat.—Soon after Baron Liebig's process for extracting and preserving the nutritive principles of meat had been perfected, an enterprising German established works for the treatment of meat on this principle in South America, a situation where cattle abound, and the meat is of little commercial value on account of the impossibility of shipping it to a market. By this

process of concentration, a single pound of meat extract is said to represent a quarter of a hundred weight of the best beef, and, in such small bulk, may be transported very advantageously. The enterprise above mentioned proving very successful, the proprietor then went to Europe and organized a joint stock company, establishing its work in the Argentine Republic, having its head office in London and its chemical laboratory in Germany, under Baron Liebig's immediate supervision. Here samples of every week's production are carefully analyzed, thus insuring the confidence of the public. The company are now capable of turning out one million pounds of beef extract annually. The extract of meat has not yet become a staple article of commerce, but is confined chiefly to the use of invalids, owing to its high price. This is more or less the case with all new manufactures; but the great success which has attended this enterprise has induced rival establishments, and we may look for competition to reduce the price to more marketable rates.

Sulphuric Acid.—A new process for the manufacture of sulphuric acid has been patented in France, by means of which it is claimed that the immense leaden chambers are dispensed with, and the entire apparatus occupies forty times less space than that required by the old plan.

The sulphurous acid gas, formed by the burning of sulphur or pyrites in compressed air, is washed before being brought in contact with the nitric vapors.

The combination takes place in a small leaden chamber so arranged that the sulphuric acid is drawn off as soon as formed. By this apparatus, it is stated in the *Mechanics' Magazine*, the sulphuric acid is obtained free from many of the impurities ordinarily found in it.

Solar Eclipse in 1868.—There is in preparation a scientific expedition into India, to take observations of the eclipse of the sun during this year; it will have an extraordinary duration, presenting an exceptional interest. The English astronomers have chosen a station situated in the chain of the Himalaya mountains at an elevation of 7000 feet above the sea, in order to augment the chances of escaping the clouds. They bring with them the instruments necessary to study from all points of observation possible—the rose-tribe protuberances—the origin of which is still so obscure.—*Cosmos.*

The Hicks Engine.—Some time since we drew attention to the

above invention, and stated that we hoped shortly to furnish our readers with a full account and description, accompanied by drawings. Various alterations and improvements have, however, delayed the preparation of these last, and we have not even now received the full material. From time to time, however, favorable accounts have reached us, and among these is the report which we give herewith, a report furnished, as will be seen, by a gentleman of high professional standing, and in a position securing ample means of investigation.

REPORT OF MR. MARK B. HORNE, Mechanical Expert and Chief Engineer of the Merrimack Mills, Lowell, Mass:—

MIDDLESEX MECHANICS' ASSOCIATION,
Lowell, Mass., October 11th, 1867.

This is to certify that I have examined and tested, as an expert, at the request of the Committee of Judges, in the Department of Machinery, at the Fair of the Middlesex Mechanics' Association, now open in the City of Lowell, a W. C. HICKS Patent Steam Engine, in use at the Works of the Salem Machine Co. at Salem, Mass., of six (6) inch cylinders and six (6) inch stroke, rated and sold as a fifteen (15) horse-power engine.

The following claims of superiority over other engines were made by the manufacturers, and submitted to me for examination, viz:—

1. That it is more correct in principle, while not conflicting with the well established theories of the best engineers.
2. That it can be more cheaply constructed.
3. That it will be more durable.
4. Greater economy in space and weight.
5. Greater economy in fuel.
6. Greater economy in lubrication and packing.
7. Greater economy in care and attention.
8. The friction being less, that it will transmit more effective power to the machinery to be driven. On these points, I give my opinion as follows:—

1. *Principle.*—It is more correct in principle, because it accomplishes the same results by a far greater simplicity of construction. Its mode of admitting, suppressing and exhausting steam, while the same in theory, is more direct, and therefore more effective and economical than in the best built modern engines.

2. *Cheaper Construction.*—This is apparent from the small num-

ber of parts—from its being almost entirely made without hand-work, and from the economy of material, the engine weighing not over one-fourth as much as other approved engines.

3. *Durability.*—From the fact that the parts are so few, and at the same time have such large bearing surface, it is apparent to me that its durability must be proportionably increased—ample evidence from parties using these engines from twelve to eighteen months was furnished me to support this opinion.

4. *Space and Weight.*—I find, by actual observation, that it occupies only about one-fourth of the space of the Corliss Engine, and weighs less than one-half as much as the balance wheel of that engine of corresponding power.

5. *Fuel.*—From the simplicity of parts, the direct operation of the steam, the reduction of friction, the diminished length of the steam-ports and clearances, and the accuracy of the valve motions, I am convinced that the claim should be admitted; and the ample testimony of parties having these engines in use, which was submitted to me, fully confirms this judgment. I learned from the shop records, that the engine examined has for the past five months performed a greater amount of work than a slide-valve engine of one of the best Boston makers, previously occupying the same place, with an average saving of 168 pounds of coal per day, in a daily consumption of 680 pounds, or 27½ per cent. under the same conditions of boiler, distance, &c.

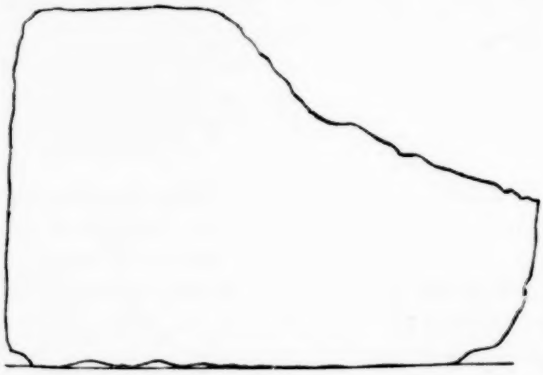
6. *Lubrication and Packing.*—The actual record of the engine examined showed an average cost of six (6) cents per day for the five preceding months (half a pound of tallow per day), or not over one-fifth the cost of lubricating the ordinary engine. Packing is entirely dispensed with, except a metallic wedge for spreading the pistons to a perfect contact with the cylinders.

7. *Care and Attendance.*—As the working parts are all under cover, and one lubrication will usually last for ten hours, the attendance required is necessarily very slight.

8. *Friction and Effective Power.*—The indicator cards taken by me, as given below, show that the power absorbed by this engine to overcome friction amounted to only 21.100 horse-power, or one and one-third per cent. of the nominal power of the machine. This is the most astonishing result in my experience, and I will let the figures carry their own inference. In my opinion, the friction varies in an almost infinitesimal degree under 1 or 100 pounds pressure

of steam, as the pressure is at an opposite angle from the wearing surface of the piston, and does not sensibly affect it.

As to the power of which this engine is capable, I will add some of the diagrams taken by me for the Board of Judges, all of which were the most absolutely perfect of any indicator cards I have ever seen taken from any engine.



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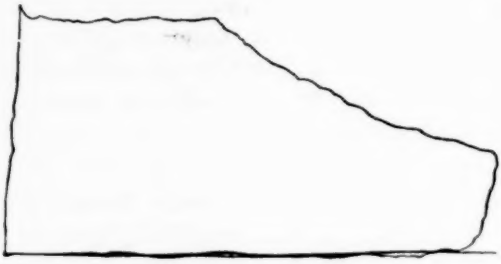

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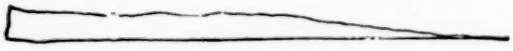


100 Rev.

Scale, 30 pounds to the Inch.

These diagrams were taken from an engine of the manufacturers' ordinary construction, such as they offer for their regular sales.

The piston area of the engine equals that of the usual double-acting engine of 8½ cylinder.

MARK B. HORNE,
Engineer Merrimack Print Works.

We also have received from Mr. Charles D. Kellogg the following account of a test with a dynamometer, made upon the same engine tested by Mr. Horne as above.

This test was made a few days since by Isaac Newton, Esq., late Engineer U. S. N., and the Chief Engineer of the *first Monitor*, when she went out to fight the Merrimac. The result was as follows, viz: 116 pounds were held up on the end of a lever 60 inches long, resting on a pulley 20 inches diameter, running 200 revolutions per minute, 80 pounds boiler pressure of steam; 116 pounds at 60 in. = 696 pounds at 10 in. or ½ diameter of pulley; speed, 20 in. × 3 + = 60 + in. or 5·236 feet × 200 = 1047·2 feet per minute; 696 × 1047·2 = 728,851 ÷ 33,000 = $22\frac{98}{100}$ horse-power. This shows the *effective* power of the engine to be nearly equal to the gross estimated power, and that the friction is reduced to minimum. This, in connection with Mr. Horne's card of the engine without work, shows that our engine has far more effective power than any on record.

As to fuel, we average in our own shop, in Newark, 3⅔ pounds coal per hour per horse-power, on a 6-horse engine, without expansion. A 10-horse engine, cutting off at half stroke, of which exact records have been kept, averages 3¼ pounds per hour per horse-power; while a 20-horse engine cutting off at about ⅜ds, stroke, at work in a grist mill, in Salem, Mass., is run with $2\frac{86}{100}$ pounds per hour per horse-power, without deductions for starting or drawing the fires. The same engine grinds nearly 50 per cent. more fine meal per hour per horse-power, than any engine builders in New England are willing to guarantee for their engines.

These tests speak most highly for the machine, and in connection with the general opinion of users which has reached us, has very great weight.

Magneto-Electric Telegraph.—A small magneto-electric machine has been successfully applied in Paris to operate a telegraphic line from Metz.

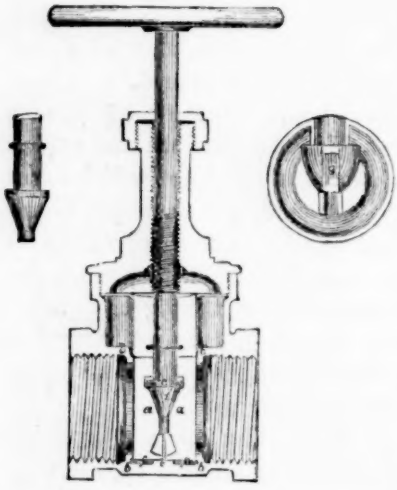
The Suez Canal has now been opened for vessels of light burden. Two schooners, some time since, passed through. One was French, the *Luzette*, the other Greek, the *Phaneroman*.

The Peet Valve.—At the last meeting of the Institute, there was exhibited this stop-valve, which is the only one of an efficient character yet furnished; which gives a straight and unobstructed passage to the flow of steam, water, or gas, which it controls.

The general structure of this valve is shown by the cut. It consists of a pair of sliding disk-plates, accurately fitted to two flat seats in the sides of the valve.

These disks are suspended and hang loosely on a collar on the stem. The end of the stem is a conical wedge; when the disks strike the bottom of the shell, this wedge is forced by the screw and hand-wheel between them, which presses them asunder, and thus drives each home on its seat.

At this point a slight turn of the wheel closes the valve *perfectly;* with a slight reverse of the hand-wheel it is entirely freed and opens without friction or resistance. This valve is equally effective against the pressure from either way, and the pressure which tends to open one side closes the other.



It has two joints, which makes it twice as effective and more than twice as durable as any single-jointed valve. For instance, a single particle of dust in the seat of a single-jointed valve causes a leak; a few hours makes that leak a permanent one. A single grain of dust in one seat of the Peet Valve would not cause a leak without the remarkable coincidence of another particle at the same time on the other seat.

This valve can always be packed under pressure of steam or water; it is machine-made throughout, every part being interchangeable, and made of the best steam metal.

The joints of this valve evidently are not effected by expansion or contraction, since any change of size in the disk or seat would simply cause a slight motion in no way influencing the joint. The joints being again at right-angles to the current passing through,

are not exposed to any filing action, as where the fluid travels across the valve-face.

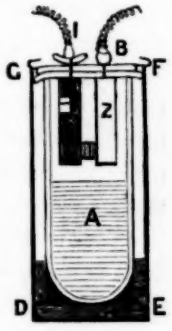
The disks can be duplicated at a trifling cost, and, the valve-faces and seats being *flat*, can always be *perfectly* repaired.

Being perfectly symmetrical, either end may be an *inlet*, and its shell is capable of resisting all ordinary strain.

The valves exhibited on the occasion above mentioned, were sent by Messrs. Foreman & Battles, 24 North Sixth street, Philadelphia, agents for the State of Pennsylvania, and were made by the American Tool Company of Boston.

New Portable Battery, by C. T. Chester, New York.—At a late meeting of the Franklin Institute, there was exhibited and described, by means of diagrams, a new form of carbon Smee battery, which is eminently fitted for transportation, and for use in locations where any escape of acid would be highly objectionable.

The accompanying cut will give some idea of its principle. A short test-tube or like vessel contains the dilute sulphuric acid or acid sulphate of mercury, A, which is employed as an exciting fluid, and is closed at top by a zinc cover, F G, having a piece of soft rubber beneath it to secure a tight joint, and held in place by an elastic band attached to hooks or lugs, F G, and passing under a block, E D, in which the tube or vessel is set. The elements, zinc and carbon, are suspended from the cover, the carbon being insulated by a rubber washer. The connections between successive cells are made by spiral springs of brass wire, I, which are thrust over rounded conical points attached to each element, as shown in the cut. The elements do not enter the liquid when the cell is in an erect position, but action is established by inverting the apparatus. A battery of ninety-five such cells was exhibited on the occasion mentioned, and was found to operate in the most satisfactory manner. In connection with various telegraphic instruments it produces remarkable effects, and in medical use occasions contractions that no induced current will produce.



Explosion of an Oxygen Reservoir.—We have just received from Dr. Wilkinson of New York, who is associated with Dr. Doremus in the preparation and arrangement of his impressive experiments, the following account, which he was kind enough to

furnish in answer to inquiries which we made when preparing an account of the fatal explosion in West Philadelphia. (See page 4.) Dr. Wilkinson's letter did not reach us until the above notice had been printed, and could not therefore be given in connection with it, as we should have wished; but will be of no less interest and value to all concerned in such manipulations. We quote from the Doctor's letter, the portion having reference to this subject. He says:—

"The explosion to which you refer occurred in this way. We at the time employed a large copper flask of some four quarts capacity, in which was placed two or three pounds of the oxygen mixture; the cap secured tightly, then placed on a furnace on a bed of hot coals, an India rubber tube attaching it to a bag of the same material. It took some time before the gas commenced to make. When it did commence, the flask was red-hot; then it came off freely; but just as it was about ceasing, a tremendous explosion occurred, throwing a large twelve-feet table to the ceiling, smashing every pane of glass in the laboratory, bursting open all the doors, and last, not least, throwing Mr. Zincker, who was alone at the time in the room, through a door into an adjoining room, where he says he recovered himself, and immediately looked for his spectacles, which to this day have not been found. That an explosive mixture was formed, he has not a particle of doubt; but as to its exact composition, he has not made up his mind. I have often made oxygen in a glass flask, using a flexible tube to convey it to the jars without any bad results following. But when a metallic flask is used, and heat applied freely, the gas passed directly into the bags, the condition of things are quite different; under such circumstances the gas gets a temperature of nearly 1100°, sufficient to decompose the hydro-carbon of which the bags are composed. Passing the gas through a wash-bottle would prevent any such accident; at any rate, I know of those that have made thousands of feet without any difficulty." In conversation with Mr. S. N. Ritchie, of Boston, we heard of two similar cases in his experience.

Artificial Grindstones of excellent quality and even texture are now manufactured from Ransom's patent concrete. Indeed, in some respects, these manufactured stones are preferable to the best Yorkshire and Durham stones. Any degree of fineness and sharpness of grit may be made, according to the materials selected. They are perfectly smooth, and have no hard spots, as the best of natural

stones are apt to have. Some extraordinary results of experiments are recorded in a late number of *Mechanics' Magazine*; but we prefer to see some further proofs, before accepting these as facts. Thus a pair of Mr. Ransom's artificial grindstones were tested against a pair of New Castle stones under similar conditions, and the results afterwards compared. A bar of steel three-quarters of an inch in diameter was kept constantly up to the face of the grindstone by means of a spring; the artificial stone was first tried and a quarter of an ounce of steel was ground away in sixteen minutes. The steel and tube were then fixed to the New Castle stone, which had a surface speed 20 per cent. greater than the other; here eleven hours were occupied in grinding away the same weight of steel (a quarter of an ounce) as the artificial stone ground off in sixteen minutes. This (counting the extra speed of the New Castle stone) is in a proportion of about 1 to 52.

Paraffine for Oiling at a High Temperature, by M. A. Monet. In the number of *Cosmos* just received, we find an article which we think well worth translating in abstract for our readers.

The oiling of machines at high temperatures, when these, for example, are above 200°, presents a great difficulty. The oils or lubricants at present in use are decomposed by the heat, and leave a residue or coating often as thick as varnish and very sticky, the adherence of which on the sides of the cylinder hinders the movement of the piston; or, to say the least of it, this coating does not perform the function of a lubricator, and packing for the capillary spaces.

In hot-air machines on the plan of Errickson, and the like, it becomes impossible fully to attain the limit at which the metallic pieces are still sufficiently strong, since it is impossible to lubricate them. When the oily materials are thick and changed, the rubbing parts adhere, and cut against themselves under the force of the pressure.

The problem then is to find a lubricating substance unalterable at 300° or 400°, and cheap enough to be employed on a large scale.

The class of paraffines furnish a substance called *mèlène* (C^{60} H^{60}) insoluble in water, soluble in the fixed oils, volatile without decomposition, and not boiling under 370°, and at the ordinary temperature it is of the consistency of wax, and floats on the surface of cold water. Paraffine has long been known as an infallible preservative of metals against oxidation. It is an excellent preservative on brass-work, protecting it from the ravages of rust, verdigris, or the moisture from handling.

A New Anæsthetic.—Dr. Richardson has lately given to the world a new and valuable substance whereby anæsthesia may be produced without the risk which has hitherto attended the use of chloroform. This substance is the bichloride of methylene. It is stated that no pain attends its use, and the effects are produced in a very short space of time. Perfect insensibility was produced in one case in four minutes, and another in six minutes.

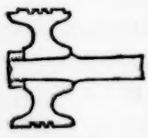
A New Railroad has been authorized by the Emperor of Brazil to be constructed. The road will have its terminus in the city of the Rio Grande de Sue, and is expected to reach the coal regions in the interior of the empire.

Waste Coal Dust has lately been utilized in this country as fuel, by injecting it by means of a current of compressed air into the space over the fire, where it is said to burn with an intensely hot flame.

The Supply of Pure Water for London.—This question has of late been engaging much attention among engineers. One of the plans proposed lately, is that of sinking about fifty artesian wells in different parts of the city, on the vertebraical principle. It is supposed that at a distance of 600 yards down, there is an unlimited supply of water. The estimated cost of the work of constructing these fifty wells is $5,000,000, and it is calculated that each well will raise and distribute four million gallons per day of twenty-four hours.

Self-adjusting Piston.—We have received from Mr. Wm. A. Sweet, of the firm of Sweet, Barnes & Co., the following description:—In the construction of this piston I adopted this plan:—I bored the cylinder as perfect as I could, then fitted the piston as tight as two men could move it; then set a heavy sharp tool in the lathe, and carried the point against the face of the piston. Now I had the piston taken to a kettle of boiling water, and plunged in and left there, until I was satisfied that it had obtained the temperature of the water. Then took it to the lathe, and put it in and started a chip as soon as it could be done; this gave me the size of the piston. I then let the piston get cold, or the same temperature as the cylinder; set the tool forward, and turned the piston off. This leaves the solid piston as large as I think is safe to leave it. The bronze rings I make $\frac{3}{8}$-inch for a 12-inch piston. This I have adopted as a standard proportion, increasing $\frac{1}{32}$ for an inch for one inch diameter of cylin-

Fig. 1.



der. The steam space, A, Fig. 2, will let the steam under the piston, and help carry the weight of the piston from the bottom of the cylinder, and the little knob, B, Fig. 3, keeps the rings from working round.

Fig. 2.

The advantage of this piston is, that your engineer has nothing to meddle with. The same ring casting will make two sets of these rings, and they can be fitted to a solid calliper, and are ready to step in at any time in a few minutes. From my experience thus far, I think one set will last one year without any appreciable wear of the cylinder. I believe the Ramsbottom piston is the best now in use; unless it is those which I have made and introduced, the technical improvements of which I have described.

Fig. 3.

Editorial Correspondence.

NEW RAPID TELEGRAPH.

THE Abbé Moigno, who for many years contributed largely, as co-editor, to the usefulness and success of the *Cosmos*, has lately accepted an engagement as regular Paris Correspondent to the English *Chemical News*. His letters to that Journal display alike his excellent command of our language and extensive connection with all that is going on in the wide field of scientific novelty. It is thus with peculiar pleasure that we have received from him a letter for the *Journal*, which he proposes to follow up with others from time to time.—EDITOR.

PARIS, *December 28th*, 1867.

Since the 11th September, 1867, the administration of the French telegraphic lines uses, for its service between Paris and Lyons, a new system of rapidly telegraphing, the invention of M. M. Chaurapaignes and Lambrig, telegraph assistants.

This telegraph acts automatically, transmitting despatches between two towns at the rate of 120 to 180 despatches per hour, by a single conducting wire, a velocity already equal to three times that of other telegraphs, and capable of being augmented proportionally to the diameter of the conductor.

The transmissions are made by means of a band of metallic paper on which the signals composing the despatch are traced with insulating ink. The reproduction is obtained on a band of unsized paper, the middle portion of which is impregnated with a chemical liquor, necessary for the formation of the signs existing on the metallic band.

In order to obtain regularity of execution, the work, such as the composition, transmission, and reception, is divided among a certain number of hands, according to requirement.

One and the same instrument in communication with the line, is composed of—

1. A clock-work movement; 2. A double roller, which draws either the metallic band or the chemical one; 3. A ringing apparatus for warning the corresponding clerk; 4. A Morse manipulator or key of ordinary construction.

The clock-work is put in movement by a weight which is wound up by a crank; it sets the rollers in motion.

Near the roller on which the metallic band passes, is a point which represents the extremity of the conducting wire. The roller communicates with an electric battery. When the band is drawn by the roller, the point is sometimes on the metallic portions of the band, and sometimes on the surfaces containing the writing of the despatch in insulating ink, thus producing emissions and cessations of the current, according to the signification of the message.

Near the roller, where the band of unsized paper passes, there is a small cup filled with a liquor composed of water, nitrate of ammonia and ferro-cyanide of potassium. In the midst of this cup is placed a small roller, which dips into the cup by its lower portion. The upper portion is a little higher than the edges of the cup, and thus supports the band of unsized paper, which, being drawn by the rollers, causes the little roller to revolve in the cup, and to leave on the paper a thin film for the reproduction of the signals when the current passes. This film extends through the paper immediately, and disappears immediately.

An iron point, representing, as that of the metallic band, the extremity of the line, rests by its own weight, slightly inclined, upon the fillet in communication with the earth, the electric current decomposes the humid portion and leaves a colored deposit, which represents the signals of the despatch.

The working of this instrument is so simple and self-acting, that

one clerk can manage it perfectly without fatigue. He can prepare from thirty-five to forty despatches per hour; the assistants acquainted with the Morse instrument can compose the despatches. For the composition of the transmission between Paris and Lyons, three composing clerks are sufficient.

We have received the following communication from M. Bertsch, of Paris, relative to a note, inserted in the *Mondes* of the 21st November, from Mr. Morton, of Philadelphia; an extract will suffice:—

"M. Morton, après avoir observé, comme beaucoup de physiciens, que dans la machine de Holtz, telle que la construit M. Ruhmkorff, le courant va en s' affaiblissant pour cesser tout à fait au bout de quelques semaines, a cru reconnâitre que l' amoindrissement graduel des effets devait être attribué à un decollement partiel des bords des armatures. En conséquence a fractionnel le plateau fixe pour pouvoir aisément, dit il, en changer les différents segments lorsque la machine ne fonctionne plus, &c."

Mr. Morton, after having observed, as many physicists have done, that, in the Holtz machine as constructed by Mr. Ruhmkorff, the current decreases gradually, and then ceases altogether at the end of a few weeks, thinks that the gradual decrease of the effects must be attributed to a loss of insulation occurring at the edges of the armatures. Consequently, he has divided the fixed plate, in order, says Mr. Morton, to exchange the different segments when the machine will no longer work. It is only necessary to glance at the details of this construction and the figures accompanying the note, to see that it enormously complicates the organs of the machine so elegantly and skillfully combined by Mr. Ruhmkorff. Mr. Morton does not seem to me to have remedied the inconvenience, more apparent than real, which is avoided, in the meantime, while preserving the excellent dispositions of the machine.

The weakening of the current cannot be attributed to the cause assigned by Mr. Morton. It depends on a superficial modification of the surfaces in front of each other. The disks covered with shellac get covered gradually with organic matter, which in inhabited places soon tarnishes all polished bodies, such as glass, mirrors, &c.

Under the progressive influence of this sufficiently conducting surface, the rotating plate ceases by degrees to become polarized. It becomes electrified by taking a portion of the charge from the armatures; on the other hand, these latter, from the same cause, communicate between each other by means of the fixed plate, which has

become a conductor, and which causes a current to be established, and the machine stops. The simplest remedy for this, is to pass between the isolating surfaces a pad of soft paper, imbibed with a few drops of turpentine, naphtha oil, benzine, or petroleum oil, so as to restore all its energy to this curious machine.

F. Moigno.

We are very far from wishing to take any advantage of our position, as nearer to our readers, to depreciate the arguments or ability of M. Bertsch, whose reasons have been repeated as above by our learned correspondent. Mr. Bertsch, as will be seen by reference to this *Journal*, Vol. LIII., page 36, is the author of one of the first and most admirable improvements on the Holtz machine, and is thoroughly conversant with its theory. In the present case, we think he is, however, hasty in his conclusions. The drawings to which he refers are those representing the modified forms of the Holtz machine made by Mr. Chester and Mr. Ritchie and published in the *Journal*, Vol. LIII., pp. 253 and 344, and which we afterwards sent, with the note or description mentioned, to *Les Mondes*. The drawings might naturally suggest to one inspecting them for the first time the idea of complication. But we, who have the advantage over M. Bertsch, that we have in our own possession both forms of the machine (that of Ruhmkorff and the new American modification), find, from absolute use and experience, that the latter is not only infinitely more easy to manage, but is likewise far cheaper and more simple in construction. Cutting the stationary plate into four, makes, to be sure, four pieces in place of one; but as these four need but one support apiece, and the entire plate required four, nothing is lost here, while, on the contrary, a great gain is secured with reference to other parts, and the facility of renewal.

As regards the remedy suggested by M. Bertsch, we sincerely wish that it were effective. It is the plan advised by the inventor in his first description, and we tried it at once, when our machine, made by Ruhmkorff, first failed, but without effect.

The varnishing of the edge of the paper, however, we have repeatedly found most efficient. This, however, only shows that there are certain conditions not yet fully understood which have a great influence. We do not for a moment doubt that the cleaning process has succeded with M. Bertsch; but as it certainly fails with our apparatus, it is well to bear both remedies in mind.

Civil and Mechanical Engineering.

ON THE ADHESION OF LEATHER BELTS TO CAST IRON PULLEYS.

By Henry R. Towne.

The following experiments, undertaken at the instance of Mr. Robert Briggs, had for their object to determine, in a satisfactory and conclusive manner, the true value of the co-efficient of friction of leather belts on cast iron pulleys. This result has, it is hoped, been attained, and in the January number of this *Journal* Mr. Briggs has discussed at length the theory of the action of belts, and has also given practical formulæ in which the co-efficient of friction employed is that deduced from these experiments, which latter have been made with great care, and may, it is believed, be accepted as reliable. In order, however, that all interested may judge for themselves of the correctness of the deductions made from them, we present herewith a complete tabular record of the experiments, which will also repay examination as exhibiting several interesting and instructive facts connected with the efficiency of leather belts.

The experiments were made with leather belts of three and six inches width and of the usual thickness—about $\frac{3}{16}$ths of an inch. The pulleys used were respectively of 12, 23$\frac{5}{8}$, and 41 inches diameter, and were in each case fast upon their shafts. They were the ordinary cast iron pulleys, turned on the face, and, having already been in use for some years, were fair representatives of the pulleys usually found in practice.

Experiments were made first with a perfectly new belt, then with one partially used and in the best working condition, and, finally, with an old one, one which had been so long in use as to have deteriorated considerably, although not yet entirely worn out. The adhesion of the belts to the pulleys was not in any way influenced by the use of unguents or by wetting them;—the new ones when used were just in the condition in which they were purchased—the others in the usual working condition of belts as found in machine shops and factories—that is, they had been well greased and were soft and pliable.

The manner in which the experiments were made was as follows:—The belt being suspended over the pulley, in the middle of its length, weights were attached to *one* side of the belt, and increased until the latter slipped freely over the pulley; the final, or *slipping* weight,

was then recorded. Next, 5 lbs. were suspended on *each* side of the belt, and the additional weight required upon *one* side to produce slipping ascertained as before, and recorded. This operation was repeated with 10, 20, 30, 40, and 50 lbs., successively, suspended upon both sides of the belt. In the tables these weights, *plus* half the total weight of the belt, are given as the "equalizing weights" (T_2 in the formulæ), and the *additional* weight required upon one side to produce slipping, is given under the head of "unbalanced weights;" this latter, *plus* the equalizing weight, gives the total tension on the loaded side of the belt (T_1 in the formulæ).

The belt, in slipping over the pulley, moved at the rate of about 200 feet per minute, and with a constant, rather than increasing, velocity; or, in other words, the final weight was such as to cause the belt to slip smoothly over the pulley, but not sufficient to entirely overcome the friction tending to keep the belt in a state of rest. In this case (*i.e.* with an excessive weight) the velocity of the belt would have approximated to that of a falling body, while in the experiments its velocity was much slower, and was nearly constant, the friction acting precisely as a brake. By being careful that the final weight was such as to produce about the same velocity of the slipping belt in all of the experiments, reliable results were obtained.

It became necessary to make use of a weight such as would produce the positive motion of the belt described above, as it was found impossible to obtain any uniformity in the results when the attempt was made to ascertain the minimum weight which would cause the belt to slip. With much smaller weights *some* slipping took place, but it was almost inappreciable, and could only be noticed after the weight had hung for some minutes, and was due very probably to the imperceptible jarring of the building. After essaying for some time to conduct the experiments in this way, and obtaining only conflicting and unsatisfactory results, the attempt was abandoned, and the experiments made as first described.

In this way, as may be seen, results were obtained which compare together very favorably, and which contain only such discrepancies as will always be manifest in experiments of the kind. It is only by making a great number of trials and averaging their results, that reliable data can be obtained.

The value of the co-efficient of friction which we deduce from our experiments, is the mean of no less than one hundred and sixty-eight distinct trials.

It will noticed, however, that the co-efficient employed in the

formulæ is but *six-tenths* of the full value of that deduced from the experiments, the latter being 0·5853 and the former 0·4229. This reduction was made, after careful consideration, to compensate for the excess of weight employed in the experiments over that which would just produce slipping of the belt, and may be regarded as safe and reliable in practice.

A note is made, over the record of each trial, as to the condition of the weather at the time of making it—whether dry, damp, or wet,—and it will be noticed that the adhesion of the belts to the pulleys was much affected by the amount of moisture in the atmosphere. It is to be regretted that this contingency was not provided for, and a careful record of the condition of the atmosphere kept by means of an hygrometer. The experiments indicate clearly, however, that the adhesion of the old and the partially-used belts was much increased in damp weather, and that they were then in their maximum state of efficiency. With the new belts the indications are not so positive; but their efficiency seems to have been greatest when the atmosphere was in a dry condition.

Experiments were also made upon the tensile strength of belts, with the following results:—The weakest parts of an ordinary belt are the ends through which the lacing holes are punched, and the belt is usually weaker here than the lacing itself. The next weakest points are the *splices* of the several pieces of leather which compose the belt, and which are here perforated by the holes for the copper rivets. The strengths of the new and the partially used belts were found to be almost identical. The average of the trials is as follows:—

Three-inch belts broke through the lace holes with						.....	629 pounds.
"	"	"	"	rivet	"	.....	1146 "
"	"	"	"	solid part	"	.....	2025 "

These give as the strength *per inch of width.*

When the rupture is through the lace holes						....	210 pounds.
"	"	"	"	rivet	"	....	382 "
"	"	"	"	solid part		....	675 "

The thickness being $\frac{7}{32}$ inch (=·219), we have as the tensile strength of the leather 3086 lbs. per square inch.

From the above we see, that 200 lbs. per inch of width is the ultimate resistance to tearing that we can expect from ordinary belts.

The experiments herein described are strikingly corroborative of those already on record, and this gives increased assurance of their reliability, and, although there is nothing novel either in them or in their results, it is hoped that they will prove of interest, and that an examination of them will lead to confidence in the formulæ which are based upon them.

THREE-INCH NEW BELT.

ON 12-INCH PULLEY (BETWEEN SEAMS).						ON 12-INCH PULLEY (ON SEAMS).					
Equalizing weights, or initial tension on each side of belt T_2.	Unbalanced weight—Trial No. 1.	Unbalanced weight—Trial No. 2.	Unbalanced weight—Average of trials.	Total weight on loaded side of belt when belt slipped $= T_1$.	$\frac{T_1}{T_2}$	Equalizing weights, or initial tension on each side of belt $= T_2$.	Unbalanced weight—Trial No. 1.	Unbalanced weight—Trial No. 2.	Unbalanced weight—Average of trials.	Total weight on loaded side of belt when belt slipped $= T_1$.	$\frac{T_1}{T_2}$
	Damp.	Dry.					Damp.	Damp.			
2·94	17	20	18·5	21·44	7·29	2·94	14	14	14·0	16·94	5·76
7·94	43	58	50·5	58·44	7·36	7·94	30	32	31·0	38·94	4·90
12·94	70	86	78·0	90·94	7·03	12·94	48	51	49·5	62·44	4·83
22·94	108	167	137·5	160·44	6·99	22·94	92	87	89·5	112·44	4·90
32·94	124	226	175·0	207·94	6·31	32·94	107	110	108·5	141·44	4·29
42·94	159	311	235·0	277·94	6·47	42·94	134	138	136·0	178·94	4·17
52·94	210	343	276·5	329·44	6·22	52·94	191	188	189·5	242·44	4·58
Mean.....					6·810	Mean.....					4·775

THREE-INCH NEW BELT.

ON 23⅝-INCH PULLEY.						ON 41-INCH PULLEY.					
Equalizing weights, or initial tension on each side of belt = T_2.	Unbalanced weight—Trial No. 1.	Unbalanced weight—Trial No. 2.	Unbalanced weight—Average of trials.	Total weight on loaded side of belt when belt slipped = T_1.	$\frac{T_1}{T_2}$	Equalizing weights, or initial tension on each side of belt = T_2.	Unbalanced weight—Trial No. 1.	Unbalanced weight—Trial No. 2.	Unbalanced weight—Average of trials.	Total weight on loaded side of belt when belt slipped = T_1.	$\frac{T_1}{T_2}$
	Damp.	Damp.					Dry.	Dry.			
2·94	12	16	14·0	16·94	5·76	2·94	13	13	13·0	15·94	5·42
7·94	34	44	39·0	46·94	5·91	7·94	38	39	38·5	46·44	5·85
12·94	54	77	65·5	78·44	6·06	12·94	55	61	58·0	70·94	5·48
22·94	110	135	122·5	145·44	6·34	22·94	.....	.....	.....	.....	.....
32·94	161	191	176·0	208·94	6·34	32·94	188	176	182.0	214·94	6·53
42·94	207	234	220·5	263·44	6·14	42·94	.....	.....	.....	.....	.....
52·94	277	282	279·5	332·44	6·28	52·94	289	295	292·0	344·94	6·52
Mean.....					6·118	Mean.....					5·960

THREE-INCH BELT.

PARTIALLY USED AND IN GOOD ORDER—ON 12-INCH PULLEY.

Equalizing weight, or initial tension on each side of belt = T_2.	Unbalanced weight—Trial No. 1.	Unbalanced weight—Trial No. 2.	Unbalanced weight—Trial No. 3.	Unbalanced weight—Trial No. 4.	Unbalanced weight—Trial No. 5.	Unbalanced weight—Average of trials.	Total weight on loaded side of belt when belt slipped = T_1.	$\frac{T_1}{T_2}$
	Damp.	Damp.	Wet.	Dry.	Dry.			
3·2	13	14	26	12	11	15·5	18·7	5·84
8·2	34	36	53	32	32	37·4	45·6	5·56
13·2	57	63	77	50	50	59·4	72·6	5·50
23·2	102	109	149	90	99	109·8	133·0	5·73
33·2	123	128	226	144	144	153·0	186·2	5·61
43·2	174	185	299	183	.....	210·2	253·4	5·87
53·2	226	265	338	249	.....	268·5	322·7	6·07
Mean								5·754

THREE-INCH BELT—PARTIALLY USED AND IN GOOD ORDER.

ON 41-INCH PULLEY.						ON 23⅝-INCH PULLEY.						
Equalizing weights, or initial tension on each side of belt = T_2.	Unbalanced weight—Trial No. 1.	Unbalanced weight—Trial No. 2.	Unbalanced weight—Average of trials.	Total weight on loaded side of belt when belt slipped = T_1.	$\frac{T_1}{T_2}$	Equalizing weights, or initial tension on each side of belt = T_2.	Unbalanced weight—Trial No. 1.	Unbalanced weight—Trial No. 2.	Unbalanced weight—Trial No. 3.	Unbalanced weight—Average of trials.	Total weight on loaded side of belt when belt slipped = T_1.	$\frac{T_1}{T_2}$
	Dry.	Dry.					Damp.	Damp.	Dry.			
3·2	26	25	25·5	28·7	8·97	3·2	23	22	23	22·6	25·8	8·06
8·2	59	55	57·0	65·2	7·95	8·2	53	54	53	53·3	61·5	7·50
13·2	86	82	84·0	97·2	7·36	13·2	86	89	82	85·6	98·8	7·48
23·2	.....	.....	.....	.....	.....	23·2	.....	.....	141	.....	.....	.....
33·2	188	194	190·5	223·7	6·74	33·2	194	210	181	195·0	228·2	6·87
43·2	.....	.....	.....	.....	.....	43·2	.....	.....	223	.....	.....	.....
53·2	306	323	314·5	367·7	6·91	53·2	285	316	272	291·0	344·2	6·47
Mean					7·586	Mean						7·276

THREE-INCH OLD BELT.

ON 12-INCH PULLEY.						ON 23⅝-INCH PULLEY.					
Equalizing weights, or initial tension on each side of belt = T_2.	Unbalanced weight—Trial No. 1.	Unbalanced weight—Trial No. 2.	Unbalanced weight—Average of trials.	Total weight on loaded side of belt when belt slipped = T_1.	$\frac{T_1}{T_2}$	Equalizing weights, or initial tension on each side of belt = T_2.	Unbalanced weight—Trial No. 1.	Unbalanced weight—Trial No. 2.	Unbalanced weight—Average of Trials.	Total weight on loaded side of belt when belt slipped = T_1.	$\frac{T_1}{T_2}$
	Damp.	Damp.					Damp.	Wet.			
2·75	12	13	12·5	15·25	5·55	2·75	16	20	18 0	20·75	7·55
7·75	35	39	37·0	44·75	5·77	7·75	48	70	59·0	66·75	8·61
12·75	61	66	63·5	76 25	5·98	12·75	72	106	89·0	101·75	7·98
22·75	102	109	105·5	128·25	5·64	22 75	157	174	165·5	188 25	8·27
32·75	142	158	150·0	182·75	5·58	32·75	220	232	226·0	258·75	7·90
42 75	203	220	211·5	254·25	5·95	42·75	256	276	271 0	313·75	7·34
52·75	259	273	266·0	318·75	6·04	52·75	301	311	306 0	358·75	6·80
Mean.....					5·787	Mean.....					7·778

SIX-INCH NEW BELT.

On 23½-inch pulley.					On 41-inch pulley.			
Equalizing weights, or initial tension on each side of belt = T_r	Unbalanced weight— Trial No. 1.	Unbalanced weight— Trial No. 2.	Unbalanced weight— Average of trials.	Total weight on loaded side of belt when belt slipped = T_1.	$T_1 \mid T_2$	Equalizing weights, or initial tension on each side of belt = T_r	Unbalanced weight— Trial No. 1.	Unbalanced weight— Trial No. 2.	Unbalanced weight— Average of trials.	Total weight on loaded side of belt when belt slipped = T_1.	$T_1 \mid T_2$
6·75	30	Damp. 36	33·0	39·75	5·89	6·75	32	29	30·5	37·25	5·52
11·75	53	63	58·0	67·75	5·77	11·75	53	50	51·5	73·25	6·23
16·75	78	81	79·5	96·25	5·75	16·75	72	72	72·0	88·75	5·30
26·75	125	135	130·0	156·75	5·86	26·75	118	115	116·5	143·25	5·36
36·75	161	177	169·0	205·75	5·60	36·75	159	176	167·5	204·25	5·55
46·75	216	223	219·5	266·25	5·70	46·75	209	236	222·5	269·25	5·76
56·75	265	269	267·0	323·75	5·70	56·75	265	275	270·0	326·75	5·76
Mean.....					5·752	Mean.....					5·640

THE SUPPORTING POWER OF PILES, BOTH OF WOOD AND IRON, AND THE USE OF THE LATTER, EITHER AS PILES OR COLUMNS OF SUPPORT FOR FOUNDATIONS.*

A PAPER READ AT THE FRANKLIN INSTITUTE JANUARY 15, 1868, BY HON W. J. McALPINE, LATE STATE ENGINEER OF NEW YORK, ENGINEER IN CHIEF OF THE U S. DRY-DOCK AT BROOKLYN, MEMBER OF THE INSTITUTION OF CIVIL ENGINEERS OF LONDON, MEMBER OF THE FR. INST., &c.

Summary.

THE formulæ of Weisbach and Saunders for the sustaining power of wooden piles, widely differ in their applications, made by these authors, of the load which can be safely imposed.

The formula submitted by the author, is based upon numerous experiments made on piles driven into fine sand, of different sizes, different weights of and falls to the ram, and is reliable for piles driven into that kind of material.

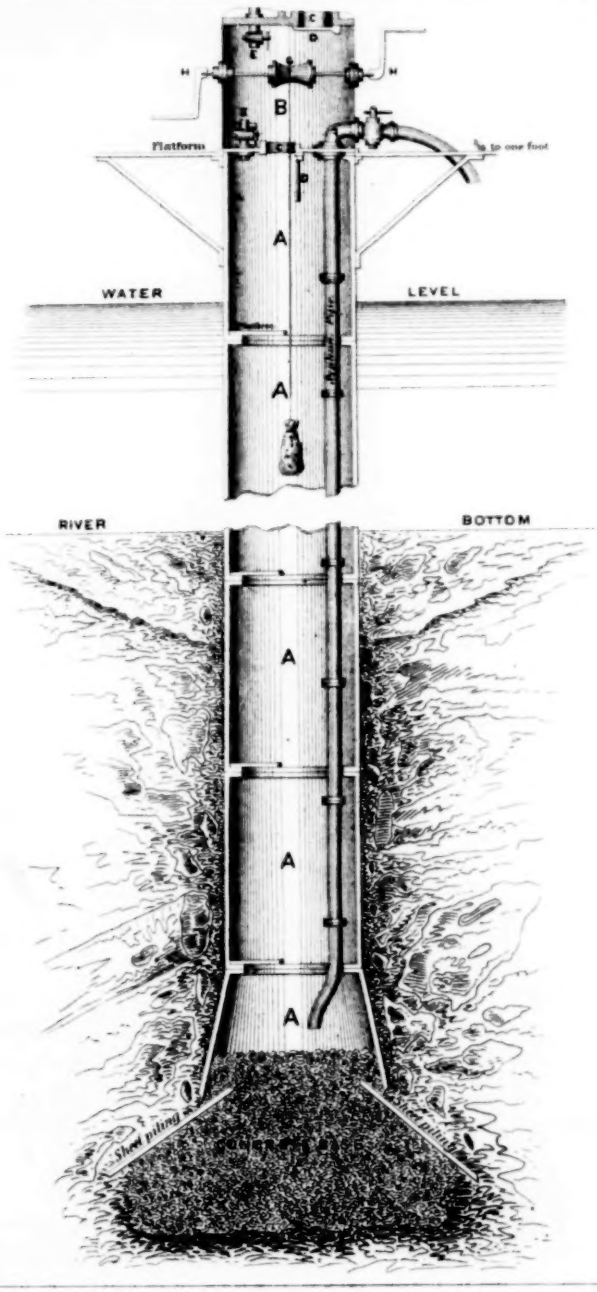
The result of these experiments showed, that within certain limits the effect of increasing the weight of the ram was to increase the supporting power in the ratio of ·7 to ·9 of such increased weight; and of increasing the fall was as the square root of such fall; that with piles of the same size, driven by the same weight of ram and fall, but to different depths, the sustaining power was as the squares of their exterior frictional surfaces; and that a pile driven home in fine sand with a ram of one ton falling thirty feet, will sustain one ton for each superficial foot of its friction surface.

Wooden piles are used either to compact the soil, as columns of support, or strictly, as piles—that is, when the support is derived from the exterior frictional surface.

These experiments also demonstrated that, with a given power, considerable advantage was gained by increasing the weight of the ram; but that any increase of the fall beyond 40 feet, in the best made machines, gave no increased penetration, and that quick blows of a heavy ram gave greater penetration at less expenditure of power, as demonstrated by the use of the Nasmyth steam pile-driver.

Experiments made on the sustaining power of the iron columns, considered as piles, at Harlem, showed that they would sustain from

* I have used the term "piles" when the support is mainly derived from the frictional surface in contact with the earth, and the term "columns" when they are driven into an unyielding material which furnishes the chief support.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Sheet piling

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one-half to three-fourths as much per square foot of frictional surface as wooden piles.

The author believes that iron piles or columns may, in certain cases, be substituted for wooden piles with economy, and sometimes that the latter (wooden piles) are inapplicable, when the former meet all the requirements of the engineer.

As an illustration of both of these opinions, he cites the railroad crossings of the large western rivers, and shows that in many cases wooden piles cannot be placed below the probable scour of the stream at any reasonable cost—that is, as compared with the expense of the iron piles—while the latter (the columns), at a moderate cost, will sustain the proposed loads with perfect safety under the deepest and most dangerous scour which has ever occurred under similar conditions.

Such iron piles may be driven when no logs or stone are encountered by the cheaper hydrostatic or excavating processes, and of small diameter, and when such obstacles are encountered, the diameter enlarged will afford the means of quickly and economically removing them by the pneumatic process. Columns of six feet diameter have been driven 25 feet in as many days, through one continued mass of boulders, and in another case through the hull of a vessel, when the wood was in perfect preservation and strongly bolted, with a delay of but two days.

Such iron piles or columns may be driven to any desired depth (even to 100 feet below the surface of the water) at a reasonable cost.

The author has introduced some new expedients in reference to these columns, which at very small cost greatly increases their sustaining power, and another, which materially lessens the cost of driving them.

The former is effected by extending the concrete filling of the columns below and outside of the bottom, and the latter by the use of air reservoirs, which enables the driver to repeat his operations upon the columns at the instant when the surrounding mass of earth is in its most loosened condition.

Doubts have been expressed whether these cast iron piles would not be burst by the severe frost of our climate, and whether the corrosion of the iron would not rapidly weaken and finally destroy them.

Such columns have stood the more severe frost of a Russian

winter, and in Scotland as well as Harlem, without the slightest injury, and nowhere does the engineer who studies the question raise this objection. In practice, the columns are sealed at both ends, and no water or moisture can get in to freeze, and if it should it would exert its expansive effort first upon the weaker material (the concrete), while the iron shell, ten times as strong, would be unaffected. The former would be compacted before any dangerous pressure would be produced upon the iron shell.

Soft graphitic iron changes its character in very foul, and slightly so in salt water; but in cast iron, when the carbon is combined, no such change occurs, and only a slight external oxidation takes place, which thereafter serves as a protection.

In fresh water even this corrosion would be inappreciable after the lapse of a century.

American engineers have generally considered this system of foundations unfavorably, from the unnecessarily expensive examples in this country, and the costly methods practised abroad; but also, perhaps, from not regarding the various modifications which may be made in the system to meet the different cases.

The material generally used has been cast iron, for which may be, under certain circumstances, substituted wrought iron, timber, and even plank. The form has generally been cylindrical, but columns of other curves and rectanglar ones may be used.

Generally the cast iron columns have sustained the loads, but the filling (in those of enlarged size) may be of solid cut stone.

The columns may be changed into a combination of diving bells and caissons, so that piers of the ordinary material and form may be founded at great depths with economy and ease, and these bell-caissons may even be made of timber and plank, and used over repeatedly.

The system, in all of its modifications, offers to the appreciative engineer, the means of safely founding his works at a most reasonable cost, and warrants more attention than it has heretofore received in this country.

ON PILE FOUNDATIONS.

PAPER IN FULL AS READ AT THE FRANKLIN INSTITUTE.

The formula which is generally used to determine the supporting power of wooden piles, is either that of Weisbach or Saunders. In the common range of practice, the results of these two formulæ do not widely differ, but the latter says that his result gives the

"safe load," while the former says that "for duration and security such piles are only loaded with from one-tenth to one-hundredth of their strength."

The formula which I have to submit to your consideration is as follows:—

$$P = 80 \cdot (W + .228\sqrt{F} - 1.)$$

Where P represents the extreme supporting power of the pile in tons; W, the weight of the ram in tons, and F the fall of the ram in feet.

This formula was derived from a number of experiments, made upon piles driven for the foundation and coffer-dams of the U. S. Dry-Dock at Brooklyn.

The gentlemen present are doubtless all familiar with the characteristics of that work, and it will only be necessary to state that the structure weighed fifty thousand tons, which had to be supported on an area of forty-four thousand square feet; but the weight could not be equally distributed, and some portions of the foundation had to sustain a weight of three or four tons per square foot.

The material as developed by the excavation, preliminary borings, and subsequent examinations to a depth of sixty feet below the foundation, was a silicious sand mixed with comminuted particles of mica and a little vegetable loam, and was generally encountered in the form of quicksand.

The material into which the foundation piles were driven was nearly uniform in character, which furnished an excellent opportunity of comparing the experiments made at different times, with hammers of different weights and falls.

It may be interesting to state, that the whole number of bearing piles driven for the foundation was 6539 and 1744 sheeting piles, acting in part as supporting piles, which gives nearly 1·7 piles per square yard, or, excluding the sheet piles, 1·4 per square yard.

These piles were chiefly of spruce timber, from twenty-five to forty feet long, and averaged thirty-two feet driven length. They were from twelve to eighteen inches diameter at the head, and never less than seven inches at the foot. They were banded with iron, and occasionally shod, but shoeing produced no increase of penetration.

The average number of blows given to each pile was seventy-three. The average distance moved by the first five blows was eight inches at each blow, by the middle five blows, three inches at

each blow, and by the last five blows from two inches to no movement at each blow.

When from any cause the piles went more than an inch at each of the last five blows, another was driven in the centre of the quadrangle, and it was found that this so compacted the material, that the adjacent piles were immovable under the effect of almost any number of blows, of a ton ram, falling thirty feet.

In other words, all of the piles were driven "home," or equivalent to such home driving. The Nasmyth hammer, it is true, produced a deeper penetration of perhaps ten per cent., but under its persuasive powers, the strongest and toughest timbers yielded.

A record was kept of the distance moved by each blow, on every pile used in the structure, and the weight and fall of the hammer.

The piling machines were unusually well made, so as to reduce the friction of the hammer in its fall, and facilitate the operations. The leaders were generally thirty-five feet long, though there was one of fifty-seven feet. The hammers were generally of a ton weight (2240 pounds), but there were some used ranging from a thousand to forty-five hundred pounds.

The experimental piles were selected so as to show the effect of the size of the pile, the weight and fall of the ram, and the rapidity of the blows, as determined by the record before alluded to.

The analysis of these experiments showed the following general laws:—

1. That when the height of the fall of the ram was increased, the sustaining power of the pile (driven home) was increased in the ratio of the square root of the fall.

2. That when the weight of the ram was increased, its effect was to increase the sustaining power of the pile by 0·7 to 0·9 times the amount of the ratio due to such increased weight.

3. That when piles of the same size were driven by the same hammer and from the same height of fall to different depths, their sustaining power was in the ratio of the squares of their frictional surfaces of penetration.

4. That a pile driven home by a hammer of a ton weight, falling thirty feet at the last blows, in such material, would sustain as many tons as there were superficial feet of exterior surface of the pile in contact with the earth, which, however, may be considered as excluding the support due to its sectional area.

The formula above stated is based upon these laws (excluding the

third), and the co-efficient is reliable for such material as was found at that place.

It is very desirable that similar experiments should be made in soils of different kinds, which would make this formula applicable to all the usual cases met with in constructions.

I have made experiments elsewhere, but unfortunately they were in soil too nearly similar to the above, to enable me to give any new co-efficients. They served to show the general accuracy of the formula given.

I may here remark, that the circumstances of each particular case must determine how much of the absolute sustaining power should be deducted to show the load which can be safely imposed upon the piles.

When there is no danger from the vibrations of the structure being communicated to the piles, nor from the scouring action of the water, they may be safely loaded with one-third of the weight determined by the formula.

The sustaining power of a pile driven home, the resistance which it meets with, and the force of the blow are, of course, equal. The subsequent subsidence of the material around the pile, however, increases its supporting power, and this varies in different kinds of soil.

This increased support cannot, however, be relied upon, if there is any subsequent vibration in the piles or scour around them.

In foundations under water, there will be a degree of fluidity given to the material by the operation of driving, which lessens the frictional resistance to the penetration of the pile; but the superior gravity of the sand to that of the water, allows it to settle in close contact with the pile, and gives a greater co-efficient of support, than if it was driven through the same kind of material in a dry state.

In comparatively slender elastic wooden piles, the vibrations caused by the blows enlarges the passage and loosens the material in contact with the sides, and although these vibrations absorb a portion of the force of the blow, they probably increase the penetration.

Wooden piles are used under the following conditions, each of which should be separately considered:—

1. To compact a soil which is not quite firm enough alone to support the superstructure.

2. As columns of support, where the material immediately below the structure is very loose, and is underlaid by a firm material; and,

3. Where the support is mainly expected from the adhesion of the adjacent material to the pile.

The first of these conditions need not be here discussed; and in regard to the second, it is only necessary to caution the young engineer that it is one of the most unsafe and dangerous kinds of foundations that he can use.

In concluding this branch of the subject, it may be added, that, with a given power, a considerable advantage is gained by increasing the weight of the ram, and, with a corresponding force of blow, less injury is done to the timber and to the iron rings.

Also, that there is no increased force of blow obtained by a fall of more than forty feet, as the friction on the ways is increased so rapidly that no increased velocity is attained by falling from a greater height. In machines less well made than those at Brooklyn, the limit of useful fall is probably thirty feet or less.

On comparing the results of the Nasmyth machine with those of the ordinary ones, it was observed, that although the force of its blows was much less, the effect was much greater.

With the former, a pile of thirty-five feet length was driven home in seven minutes, while with the other machines, an hour or more was required to drive a similar pile.

The first part of the operation did not exhibit so marked a difference between the two machines as was afterwards shown, while the piles were meeting with greater resistances.

In the first case, the force of the blow in each machine was in part absorbed by the vibrations of that part of the pile above ground; while in the latter, these vibrations, for the instant, removed the partially fluid earth from contact with the pile. The blows of the Nasmyth ram were given at intervals of less than a second of time, and before the material displaced by the vibrations of the preceding blow had had time to subside, and therefore nearly the whole force of its blow was employed in the displacement beneath the pile. In the other machines, the blows were given at intervals of a minute, by which time the vibrations had ceased, and the material had partially subsided around the pile, so that a considerable portion of the force of the blow was consumed in overcoming the friction along the sides, and in the removal by new vibrations, leaving only a comparatively small portion of the force to displace the earth at the bottom.

This effect would probably be produced in nearly all descriptions of earth, although it would be greater in loose and partially fluid material, than in clay or compact soil.

The use of the Nasmyth machine demonstrates the value of quick blows, not only in the economy of driving, but also in obtaining a deeper penetration, which is often very desirable.

The comparative cost of driving by the use of different kinds of power is nearly as follows:—

By steam with the Nasmyth ram	5·
" " ordinary machines	9·
" horse-power with " "	12·
" man-power—tread-wheel	15·
" " cranks	20·

And these sums represent cents per lineal foot of pile driven in 1846.

In February, 1861, I made some experiments to determine the supporting power of large iron columns considered as piles—that is, of the external frictional resistance. I regret that the circumstances of the case did not warrant the extraordinary expenditure necessary to determine the absolute sustaining power of iron piles, but it is interesting to know, that the piles sustained a load of 716 pounds per square foot without any movement, at a time when the material around it had been for weeks disturbed and loosened by the constant escape of air from the pneumatic process, which was being carried on at another column but six feet distant.

I am of the opinion that this column would have sustained double this load before it would have moved; but for safety, I have assumed half a ton per superficial foot of the exterior frictional surface of iron piles, which is one-half as much as I ascertained that wooden piles would bear.

The frictional resistance depends upon the extent of the surface in actual contact, which in the minute particles of sand at the Navy Yard, must give the largest co-efficient. At Harlem the silting of the same kind of fine sand between the interstices of the gravel and stone, would also give a large co-efficient, but probably not as great as the former.

The angular particles of the sharp sand would probably be indented into wooden, but not into iron piles, and, together with the less regular surface of the former, would increase its frictional resistance. A careful consideration of these circumstances, as well as of the experiments, confirm the opinion above expressed.

I have recently seen a reference to the English practice, in which

it is stated that the rule there, is to allow 600 pounds per square foot for this resistance on iron piles.

The allusion is no more definite than above stated, and does not specify whether this is the safe load or the ultimate strength, nor does it state to what kind of soil it refers. If these facts were known to us, one could determine whether it confirms or contradicts the results and opinions which I have above expressed.

It may be interesting to some of the profession present, to state how these experiments were conducted.

The main beam of the lever was a stick of Georgia pine, 60 feet long, averaging 18 by 16½ inches. The short arm was 4 feet long; the bearing points were turned steel rollers, 1½ inches diameter and 12 inches long, set in and bearing upon cast iron plates, also bored out. The lever was strongly trussed by a king-post of oak 9 feet high and 13 inches square, resting on a cast iron block, and arranged with folding wedges at the bottom, to strain the truss to its bearings. A heavy cast iron saddle was fitted to the top of the post, through which passed a large turned iron pin. The long truss rods were two bars of iron 2½ by ¾ inches, and the shorter rods of three pieces of 1⅞ inch iron, connected to a joggle by two links of iron, and by lugs of iron on a heavy plate on the main beam, and another heavy plate of iron was placed near the outer end of the main beam, to which the long truss rods were attached or hooked on lugs.

The truss was calculated to allow a strain of 150 tons to be placed upon the column, but was strong enough to have allowed twice that strain.

The leverage being 14 to 1, would have brought an uplift of 2000 tons on the fulcrum. The works were carried on in the middle of the river, from a temporary platform of piles, which would not have borne this load, and therefore we had to depend upon the combination of such load as the platform would bear, the resistance of its piles to an uplift, and a series of trusses, by means of all which the tenacity of nearly forty of the platform piles was obtained, and, in a later experiment, by using the weight and resistance of a large iron column already driven a short distance into the earth.

But the constant escape of the condensed air into the earth of the river-bed, had so loosened the hold of these platform piles, that they yielded when the uplift pressure reached seven hundred tons, and, to our deep regret, the experiment had to be discontinued, almost at the point when it would have fully demonstrated the problem so earnestly desired.

I am now desirous of calling the attention of the profession to the value of iron piles for foundations in deep water, and where the use of wooden piles is objectionable.

I commence by stating my opinion, that in difficult cases, these iron piles or columns may be substituted with economy for wooden ones, or any of the usual substitutes of coffer-dams and caissons; and with the knowledge we already have, the engineer can rest assured that with these columns his foundations can be rendered safe beyond question.

To illustrate my views, I propose to take for an example the case of our western rivers, where many bridges are now being proposed for railroad crossings, and where the like difficulties occur, as in crossing many of our Atlantic coast estuaries.

For more than twelve degrees of latitude, these western rivers, in nearly all cases, flow through valleys many times wider than the stream, and bounded on each side by high rocky bluffs, which are nearly parallel, and from one to five miles apart. These rivers always run alongside of one or the other of these bluffs; but, after following one side for five, ten, or fifteen miles, some obstruction turns them off towards the opposite bluff, which they follow until again deflected to the opposite side of the valley.

The railroad crossings must necessarily be made, where the river channel is against the bluff, on one side or the other.

The valleys between these bluffs have, at a remote day, been scoured out to a great depth, and are now filled with diluvium. The river channels have scoured out the bed next to the bluff, down to the rock, whenever it lies at less than twenty to thirty feet below low water; but as these rock slopes are steep, not more than one-third of the piers of a bridge can be founded on the rock at a reasonable depth, and for the remainder of the length of the bridge the rock is beyond reach, and the piers must be supported on the sand which has been silted into the deep chasm between the bluffs.

This material is generally silicious or mixed with calcareous matter, and some loamy earth, and never becomes a coarse sand.

The Mississippi River has a fall of from four to six inches per mile, and the Missouri of ten to sixteen inches, and the smaller navigable streams a fall between the extremes of these ranges. The currents of the former are from three to five miles an hour in low water, and reach a superficial velocity eight or ten miles in the great floods. The velocity of the Missouri is still greater.

During the floods, these rivers wear away the banks and scour out the bottom, carrying forward much solid matter in suspension, and as the floods begin to subside, this suspended matter is deposited wherever the force of the current is lessened. Thus, during freshets, the main channels are scoured out, and in some places deep holes made; as the water falls, many of these holes fill up, and so do the channels.

The river-bed is of so fine material, that this alternate scour and deposition is in constant action, and this is particularly noticeable where any obstruction is placed in the channel; a sunken vessel or a mass of flood-wood has sometimes, especially on the Missouri, changed the channel of the river for miles, scouring out holes forty feet or more in depth, or silting up islands in mid-channel.

The problem of founding piers for a bridge over such streams, is one of the most interesting to the profession. The only two bridges which now cross the Mississippi—the Rock Island and Clinton—are where there exists a chain of rocks entirely across the river; and these two places, with another at Des Moines, form the only exceptions to the description which I have above given of the general character of this stream.

The necessities of commerce, however, demand crossings at many other places than these exceptional ones, and it is the province of the engineer to meet these demands.

The careful engineer, before commencing the construction of such a bridge, will study the stream well, and ascertain the greatest depth of water which its freshet currents produce, not only at the site of the proposed bridge, but far up and down stream. He knows that no obstruction can be placed in a stream like that of a series of bridge-piers, for producing the greatest scour, and especially if an ice or drift-wood gorge should occur at his bridge, to which it is peculiarly liable, from the frequency of the obstructions, extending entirely across the channel.

Will wooden piles afford a safe foundation for such a structure? The sand of the river-bed, although so easily removed by the water, strongly resists the penetration of piles when driven in the ordinary manner. The timber is not strong enough to resist the force of a blow, or rather, the resistance of a penetration of more than twenty-five feet, though perhaps the Nasmyth machine would obtain one of thirty feet. One-half of the piers would probably, and some of them would certainly, have to be founded on one of the bars in

shallow water. If the water was in this case five feet deep at low water, and a scour of twenty-five feet only should take place, the piles would be washed out. If a pit should be dredged say to twenty feet below low water, and the pile be forced to penetrate thirty feet, and a scour of thirty feet should occur, the piles would have lost $\frac{5}{6}$ths* of their supporting power, and their number must be accordingly increased.

The expense of these additional piles, and of the curbing to keep the sand from filling the pit, and the extra cost of very long piles, would go far towards paying the cost of iron piles.

When the pit was dredged, as above stated, to give piles a penetration of thirty feet, it would require very long timbers, viz: to reach not only up to the level of low water, but five or ten feet above it, to allow the operation of driving them to be carried on, at such times as the case demands, which would rarely be in seasons of dead low water.

The vibrations of such long timbers would absorb some of the force of the blows, and it is very doubtful whether even Nasmyth could drive them to a penetration of thirty feet.

It would then appear that the limit of the use of wooden piles for the foundations of piers under the assumed circumstances, is when the scour of the river will not reach to a depth of thirty feet below low water.

But it is well known that holes have often been scoured out to a depth of forty feet, and on the Missouri to a still greater depth; and in all such places, foundations of that sort would be wholly destroyed, and with them the valuable superstructures.

It has been said that the piers can be protected by masses of rip-rap around their base.

The use of such protection has often been tested, and in certain places is valuable. For the case in question it is valueless. Its effect would only be to produce a deeper scour at its outer extremities, into which it would tumble stone by stone, leaving the bed of the river nearer and nearer to the pier, exposed to the same scour, until finally the piles would be undermined, as if no such protection had been used.

* $20+30=50$ to the bottom of the pile. Deduct the scour of 30, and it leaves the pile but 20 feet into the earth. Its supporting power is then reduced to $\frac{20^2}{30^2}$, or a loss of $\frac{5}{6}$ths.

The worst scouring will occur in the high freshets, and its operation, concealed from view, will only be developed when the pier begins to totter, and such a supposed protection is only a delusion, which, if it is really relied on, may prove the cause of the destruction of the bridge.

But I turn from this subject, on which perhaps I have dwelt too long, to the substitution plans to which I desire now to call your attention, viz: the use of iron piles for foundations, or of large iron columns, which will not only form the piers themselves, but also their own foundations.

(To be continued.)

DEEPENING OF THE MICHIGAN AND ILLINOIS CANAL.

By S. W. Robinson, C.E.

The valley of the Des Plaines River, in the State of Illinois, is supposed to have been at some period during the geological ages, the course of a river which formed an outlet to the Great Lakes, and a tributary to the Mississippi.

The bed of this valley, at present, scarcely rises twenty-five feet above the level of Lake Michigan, the summit being only ten or fifteen miles from the lake.

The Michigan and Illinois Canal, which extends down this valley, is 96 miles in length, and joins Lake Michigan, at Chicago, with the Illinois River at La Salle. This canal was commenced about thirty years ago. It has now been in use for several years, the boats being carried over the summit by the use of locks, situated at Chicago and near Lockport, which retain the water upon a level ten feet higher than the Chicago river and Lake Michigan.

Since the city of Chicago has suffered in such a marked degree from the notable stench of the Chicago River, it has been determined to deepen this canal across the summit, so as to induce a current of water down the valley into the Illinois River. This will form an artificial river, by which water will be carried from the lakes towards the Gulf of Mexico. Although the amount of water carried to the sea by this course will be small, yet the fact will exist of two outlets to divide the waters of the great lakes, and depreciate the honors of the St. Lawrence.

The amount of deepening required to effect this, is about ten feet

between the locks above named, for a distance of 27 miles. The working depth of the canal is to be six feet, reckoned from the low water mark of Lake Michigan; the breadth of the canal at the bottom is to be 50 feet, and, six feet from the bottom, 60 feet.

This work of deepening was commenced two years ago; and will probably be finished by the middle of April, 1869. That navigation shall not be interfered with, the work is done between the middle of the months of November and April, each winter. The deepening requires the removal from the bottom of the canal of about two and a half million yards of earth, and two hundred and forty thousand yards of solid rock.

The former is contracted variously at from half a dollar to a dollar per yard, and the latter at from $2\frac{1}{8}$ to $2\frac{1}{4}$ dollars per yard.

The city is permitted by the State to prosecute this work to the extent of two and a half million dollars, with the understanding that it shall be reimbursed by revenues from the canal, if not sooner paid directly by the State, which, the writer has been informed, will be done, if the State widens the canal to 80 or 100 feet to accomodate the Mississippi flat-boats. The excavation is earth for a distance of 20 miles from Chicago, where the excavation of magnesium lime-rock commences, which extends about seven miles further, reaching nearly to Lockport.

This part of the canal runs through the limestone beds from which the excellent building stone for the city of Chicago is quarried.

To loosen the rock in the canal, blast-holes are used which are 4 to 6 inches in diameter and 6 to 10 feet deep. These have heretofore been bored by raising the drills by horse or steam-power, then letting them drop, gravity doing the work of striking the blow.

The drills principally used for this purpose are about 20 feet in length and $2\frac{1}{2}$ or 3 inches in diameter, and of iron, except at the cutting end, which is enlarged with steel to nearly the size of the hole for one or two feet, and armed with a Z-bit.

Experiments are now being made with direct-action steam drilling machines at the works of Messrs. Singer & Talcott.

Much difficulty has been experienced in effecting the speedy removal of the chips which are formed so much faster than by other appliances heretofore used for drilling. This difficulty, however, is likely to be overcome; and the time is probably near at hand when direct-action steam-drills will be used on all our great works in rock excavation throughout the country.

The rock is raised from the bottom of the canal to the banks, by means of cranes or derricks, worked by horse-power.

The cranes have the advantage of being portable, being mounted upon movable platforms. The derricks, however, perform the operation of hoisting more satisfactorily, and require less work than the cranes, as there constructed.

The easiest working derricks used there are those in which the boom would swing entirely around the mast in disposing of each load. They were so constructed that the horse or horses traveled around the mast, and in the same direction as the boom. The mast rests upon the centre of the sweep to which the horse is attached, and the friction between the mast and sweep, induced by the movement of the latter, causes the boom to move and carry the load around simultaneously with being raised, from the pit to the bank, ready to be dumped. One of the smoothest working derricks I saw, had a friction clutch for communicating power to the cable, the latter being of steel wire instead of a chain.

One horse worked this with apparently as much ease as two could the cranes, having a chain cable, and where the cranes required two to four men each, beside the driver, to manage them, the derricks required but one. These derricks were invented by A. T. Merriman & Brother of Chicago.

University of Michigan, January 20th, 1868.

WOOD HANGINGS FOR WALLS.

We have received from New York some samples of a new article of manufacture, which is intended to supersede the process of papering walls. It is to cover the walls with wood itself, and this at a less expense than covering by paper. The wood is cut into rolls so thin that a log, measuring twenty-four inches in diameter, would make one hundred and twenty-five rolls, containing thirty-six square feet each. One machine will shave two square rolls per minute, or one thousand rolls per day. We may now have our walls "hung," to match our furniture, with real walnut, mahogany, birch, rosewood, maple, poplar, or any other variety desired.

This "wood hanging" is merely a very thin veneering, and may be placed on the walls by paper-hangers in the ordinary manner.

A company has just been formed for the manufacture of this material in New York.

Mechanics, Physics and Chemistry.

LECTURE-NOTES ON PHYSICS.

By Prof. Alfred M. Mayer, Ph.D.

(Continued from page 44.)

2. *Instruments used in the Measurement of Angles.*

Note.—On page 325, vol. liv., eight line from foot, for "*to* what is called the inductive," substitute "*by* what," &c.

The circumference of the circle is divided into 360 parts, one of which is called *a degree*—the unit of angle measures. The degree is divided into 60 *minutes*; the minutes into 60 *seconds*; the subdivisions of the second are decimal. The sign of the degree is (°); of the minute (′); of the second (″).

Theodolite, Meridian Circle, Sextant, &c., described from the instruments, and from diagrams.

The Micrometer consists of two spider-lines, stretched parallel to each other, on two frames, each moved by a micrometer screw, so that the threads can be made to approach to, or recede from, each other. The spider-lines are exactly in the focus of the object glass of an achromatic telescope, so that the image of any object formed by the object-glass, and the lines, are in the same plane, and therefore both equally distinct, when viewed through the ocular of the telescope. The value of one turn of the micrometer screw may be estimated in angle units, by causing the spider-lines to embrace the vertical diameter of the sun, when it is on or near the meridian; and then, by obtaining its exact diameter from the Nautical Almanac, we can, after allowance made on our measure for refraction, reduce a turn of the screw to its value in angle.

The invention of the micrometer is due to William Gascoigne, who also first applied the telescope (invented in 1609, by Galileo) to a graduated circle. Gascoigne was killed, at an early age, while fighting for Charles I., at Marston-Moor, 2d July, 1644.

The Reading Microscope is a similar contrivance to the Micrometer; the difference being, that the micrometer spider-lines, which cross (×) each other, and are moved by one screw, are placed in the focus of a microscope, instead of in the focus of a telescope. The Reading Microscope is placed over the divisions of a graduated circle, and is so adjusted that five turns of the screw will carry the point

of bisection of the cross (×) lines, the length of the smallest division on the circle, which generally equals 5′ of arc. The head of the screw of the reading microscope is divided into 60 parts, so that when the screw is revolved through one of these parts, the cross (×) lines are carried over the circle, a distance equal to *one second* of arc. In those circles used in the most accurate determinations of astronomy, the microscopes read to $\frac{1}{10}$ of a second of arc; and this minute accuracy is absolutely required in many problems now in process of solution by Astronomers—(*e. g.* the parallax of the fixed stars).

The difficulty of measuring with accuracy to a fraction of a second, will be readily appreciated, when we know that one second of arc occupies, on a circle of 6 feet in diameter, a length of only ·0001745 of an inch.

For an excellent method of stretching spider-lines in the micrometer, devised by Lieut. M. F. Maury, see Washington Astronomical Observations, 1845.

Reflecting Goniometer. Used in the measurement of the angles of crystals. Invented by Dr. Wollaston, in 1809. "This instrument will give the inclination of planes of crystals, whose area is less than $\frac{1}{100000}$th part of an inch, to less than one minute of a degree." (Ency. Metrop. Art. Crystallography.)

Instruments exhibited, and method of using explained, by measuring the angle of a crystal.

The Spirit Level is formed of a *slightly* curved glass tube, nearly filled with ether. A bubble of air occupies the highest portion of the convex side of the tube.

Spirit levels have been made of such extreme delicacy, that an inclination of one second of arc, in the plane on which the level rests, would cause the bubble to move three millimêtres; the curvature of the tube of the level, in this case, was 619 mêtres. M. Biot used, in his measurement of the arc of the meridian passing through Dunkirk to Formentera, a level whose bubble moved one millimêtre for an inclination of 1″·79.

By the aid of the levels of the best mechanicians we can safely estimate *tenths of seconds* of arc.

The level appears to have been known to the ancient astronomers of India.

3. *Instruments used in the Measurements of Volumes.*

Volumes of liquids and of gases are measured in graduated cylindrical tubes.

A tube or vessel of any form may be graduated into cubic centimêtres, by marking the levels reached by successive equal portions of mercury poured into the tube or vessel; each portion being equal to the exact weight of one cubic centimêtre of mercury, of the temperature at which the mercury is when the weighing is performed. It is better, however, first to divide the tube into equal divisions of length, say millimêtres, on a dividing engine, and then, with a short tube, whose aperture is closed with a ground glass plate, and whose capacity is exactly one cubic centimêtre, to measure off and pour into the tube, cubic centimêtres of mercury. After each addition, the number of millimêtres to which the mercury rises is noted in a table, and thus the value in capacity of each division of the tube is deduced.

For further information on this subject, see Bunsen's *Gasometry*, London, 1857; and the papers of Regnault, published in the Transactions of the Institute of France.

Volumes of solids, as well as of liquids, may be determined by the estimation of their weight, at a known temperature, and under a known atmospheric pressure. In this method we have also to know the weight of a cubic inch, or of a cubic centimêtre of the solid or liquid. The advantage of the French gramme weight is shown in this determination of volumes, by weight; for the *specific gravity* of a body is equal to the weight of one cubic centimêtre of the substance, in grammes; for one cubic centimêtre of water, at 4° C., weighs one gramme.

4. *Instruments used to Measure Weights.*

Two units of weight are used in this country: *the grain*, fixed by the weight of one cubic inch of distilled water, at 62° F. and 30 inches of the barometer, one of such cubic inches of water weighing 252·456 grains. The other is the French unit, the gramme, which is derived from the weight of one cubic centimêtre of distilled water, at 4° C.

The Balance. Saxton's U. S. Standard Balance exhibited and described. Becker's Analytical Chemists' Balance. This balance will weigh to the $\frac{1}{10}$th of a milligramme, with each pan carrying a weight of 50 grammes; or, in other words, its beam will turn with $\frac{1}{50\,000}$th of that weight, the index being deflected $\frac{1}{2}$d of a division of the scale from the position of equilibrium.

See a paper by W. Crookes, in the *Chemical News* for 19th April,

1867, on the Correct Adjustment of Chemical Weights; and the investigations of Prof. W. H. Miller, of Cambridge, in the *Philosophical Transactions* for 1856.

Method of Double Weighing. Invented by Borda of Paris. Consists in counterpoising a mass, whose weight we desire, by shot, sand, thin copper foil, or pieces of fine wire, and then replacing the mass by weights, until equilibrium is again established. The weights are thus placed in exactly the same conditions as the mass, and therefore this process eliminates all errors arising from unequal length of the arms of the balance, etc. This process is far more accurate than single weighing.

The weights of very small portions of matter, such, for example, as *chemical traces*, can be estimated by the deflection of a very fine filament of glass, one end of which is cemented to the edge of a block, and the other end has hanging to it, a still finer filament, supporting a disk, about $\frac{1}{2000}$th inch thick, made of elder pith, on which is placed the substance, whose weight we determine by the amount of deflection it causes in the glass filament. With this apparatus can be estimated the deflection produced by the $\frac{1}{1000}$th of a millimêtre.

See a paper by the author in Silliman's *Journal of Science*, vol. xxv., page 39, 1858, describing this instrument.

5. *Instruments used in the Measurement of Time.*

Definition of time, from Laplace's Système du Monde, ch. III:—"Time is for us the impression which is left in the memory by a series of events, whose existence we are certain has been successive. Motion can serve to measure it; for a body not being able to be in several places at the same time, can only go from one point to another, by passing successively through all the intermediate points. If at each point of the line which it describes, it is animated with the same force, its motion is uniform, and the parts of that line can measure the time employed to run over them. When a pendulum at the end of each oscillation is found in exactly the same circumstances, the durations of the oscillations are the same, and time can be measured by their number. We can also employ for that measure, the revolutions of the celestial sphere, which are always equal in duration; but all have unanimously agreed to use for that object the motion of the sun, whose returns to the meridian, and to the same equinox, or to the same solstice, form the days and the years."

The duration of one revolution of the celestial sphere constitutes a sidereal day; while the time of one mean revolution of the sun equals a mean solar day. The sidereal day, which is used by astronomers, is 3m. 56·5s. less than the solar day.

Both days are divided into 24 hours; each hour into 60 minutes; and each minute into 60 seconds; the seconds are sub-divided decimally. The hours are designated by the sign *h*; the minutes by *m*; the seconds by *s*. Both days are divided into 86,400 seconds.

The real unit of time must be the *sidereal day*, being the duration of one revolution of the earth on its axis. From recorded ancient eclipses, it has been computed that the time of this revolution has not altered by $\frac{1}{1000000}$th of its length, from B. C., 720. From the sidereal day is readily deduced the value of the mean solar day.

The Astronomical Clock A clock consists of a train of wheel-work (moved by the descent of a weight) which maintains and indicates the vibrations of a seconds pendulum. The Astronomical clock is made with every refinement of workmanship; it has generally a "*dead-beat*" escapement, and has always a pendulum, which is so compensated that a change of temperature does not alter the length from the point of suspension to the centre of oscillation of the pendulum.

The Chronometer is a large watch, very accurately constructed, having a "*chronometer escapement*" and a carefully compensated balance-wheel. It beats half-seconds.

It is not required that a clock or chronometer should keep the exact time, but it *is* required that the daily *rate* of *variation* from the true time should be constant.

The pendulum clock was invented by Huyghens, of Holland, in 1658; and in the same year Hooke of England applied the spring-balance to time-keepers.

Seconds Stop-Watch exhibited and described.

A uniformly revolving cylinder was first proposed by Dr. Thomas Young, for the measurement of intervals of time. With this apparatus we can, in certain cases, measure the $\frac{1}{1000}$th of a second. "By means of this instrument, we may measure without difficulty the frequency of the vibrations of sounding bodies, by connecting with them a point, which will describe an undulated path on the revolving cylinder. These vibrations may also serve, in a very simple manner, for the measurement of the minutest intervals of time; for if a body, of which the vibrations are of a certain degree of frequency, be caused to vibrate during the revolution of an axis, and

to mark its vibrations on a roller, the traces will serve as a correct index of the time occupied by any part of a revolution; and the motion of any other body may be very accurately compared with the number of alternations marked in the same time, by the vibrating body." From Dr. Young's *Lectures on Natural Philosophy and the Mechanical Arts* (a work to be thoroughly studied by all students of physics), 2d Edit., London, 1845, page 147. See, also, an article on "Apparatus and Experiments," devised by the author, in the Franklin Institute Journal, for November, 1867.

The revolving cylinder has recently been applied to the registration of transit observations. The apparatus described, with diagrams.

Kater's Method of determining small intervals of time, by weighing the mercury which flows from a small orifice, under a constant pressure.

Revolving Mirror. Invented by Prof. J. Wheatstone, of London, who, in 1834, measured with it the velocity of electricity. Improved by Arago, and proposed by him to the Institute of France, in December, 1838, to determine the velocity of light. In 1850, Foucault of Paris, so perfected its construction and arrangement, that he measured with it, accurately, the $\frac{1}{1\,500\,000}$th of one second of time.

The principle of the apparatus can be rendered clear in a few words. Suppose a ray of light, entering a dark room by a fine slit, falls upon a rapidly revolving mirror. This ray is reflected from the *revolving* mirror to a *fixed mirror*, distant from it say 20 feet. The ray reflected from the fixed mirror, falls again upon the revolving mirror. Now, suppose that in the time the light takes to go from the revolving mirror to the fixed mirror, and to return to the revolving mirror, that by its rotation, the face of the revolving mirror changes its position: then this causes a deviation in the ray reflected on its return to the revolving mirror, compared with its direction when it left the revolving mirror to go to the fixed mirror. Therefore, knowing the time it takes for the mirror to make one revolution, we can compute, from the deviation produced, the time required by the light to go over double the distance from the revolving mirror to the fixed mirror. This distance, in Foucault's experiment of 1850, was only 4 metres (13·12 feet); and the mirror, making 800 turns in a second, produced a deviation in the return ray of $\frac{3}{10}$ millimêtre.

In 1862 Foucault repeated his measurements with a far more precise instrument, and increased the distance of the mirrors from 4 to

20 metres (65 feet 7·4 inches). The result of his measures gives a velocity of light equal to 185,177 miles per second, differing slightly from the measure obtained by astronomic observations, when we use for this reduction the solar parallax, with the increase in amount which it appears from recent observation we should adopt.

The most important result obtained with this apparatus, was the fact that light moves slower in water than in air, the velocities into two media being as 3 is to 4. In short, the index of refraction expresses the ratio existing between the velocities of light in the two media.

"An admirable experiment in physics, in which, by the power of intellect and manual skill, we have succeeded not only in rendering sensible, but even measurable, the time employed by light to run over a path of 20 metres, although this time barely equals the $\frac{1}{1\,500\,000}$th of a second! and which, if we repeat so as to vary its elements, and thus make evident the constant causes of error which affect the result, appears capable of giving a determination of the velocity of light altogether as precise as that which is deduced from astronomical phenomena!" For further information of this method, see "Essay on the Velocity of Light," by M. Delaunay of the Institute of France; translated for the Smithsonian Institution by Prof. Alfred M. Mayer, 1864.

Calculating Engines. The great importance of such machines in giving us *faultless* logarithmic, astronomical, nautical, and other tables. Impossible to calculate and print any extensive table without making errors.

For a description of the Arithmetical Machine of Pascal, see *Oevres de Pascal*, vol. ii., page 368, et. seq. Hachette, Paris, 1860.

For information in reference to Charles Babbage's celebrated engines, see *Edinburgh Review*, 1834; Taylor's *Scientific Memoirs*, vol. iii., 1843, London, in which is a description by General Menabrea, of Babbage's Difference Engine, and of his more recent and far superior Analytical Engine, translated, with extensive notes, by the accomplished Lady Lovelace, the only daughter of Lord Byron.

See also Passages from the Life of a Philosopher, by Charles Babbage, London, 1867.

Exhibit the "Tables calculated, stereomoulded, and printed by machinery," London, Longmans & Co., 1857. The engine by which these tables were calculated was made by George and Edward Scheutz, of Stockholm, and is now the property of the Dudley Observatory, at Albany, N. Y.

TABLES FOR THE COMPARISON OF THE FRENCH AND ENGLISH SYSTEMS OF MEASURES AND WEIGHTS.

Measures of Length.

Denomination and Value.		Equivalent in English Standard.
Myriametre	10,000 metres	6·2137 miles.
Kilometre	1,000 "	0·62137 mile = 3,280 feet 10 inches.
Hectometre	100 "	328 feet 1 inch.
Decametre	10 "	393·707 inches.
METRE	1 metre	39·37079 "
Decimetre	$\frac{1}{10}$ "	3·937 "
Centimetre	$\frac{1}{100}$ "	0·3937 "
Millimetre	$\frac{1}{1000}$ "	·03937 "

Measures of Surface.

Denomination and Value.		Equivalent in English Measure.
Hectare	10,000 square metres	2·471 acres.
ARE	100 " "	119·6 square yards.
Centare	1 " metre	1,550 " inches.

Measures of Capacity.

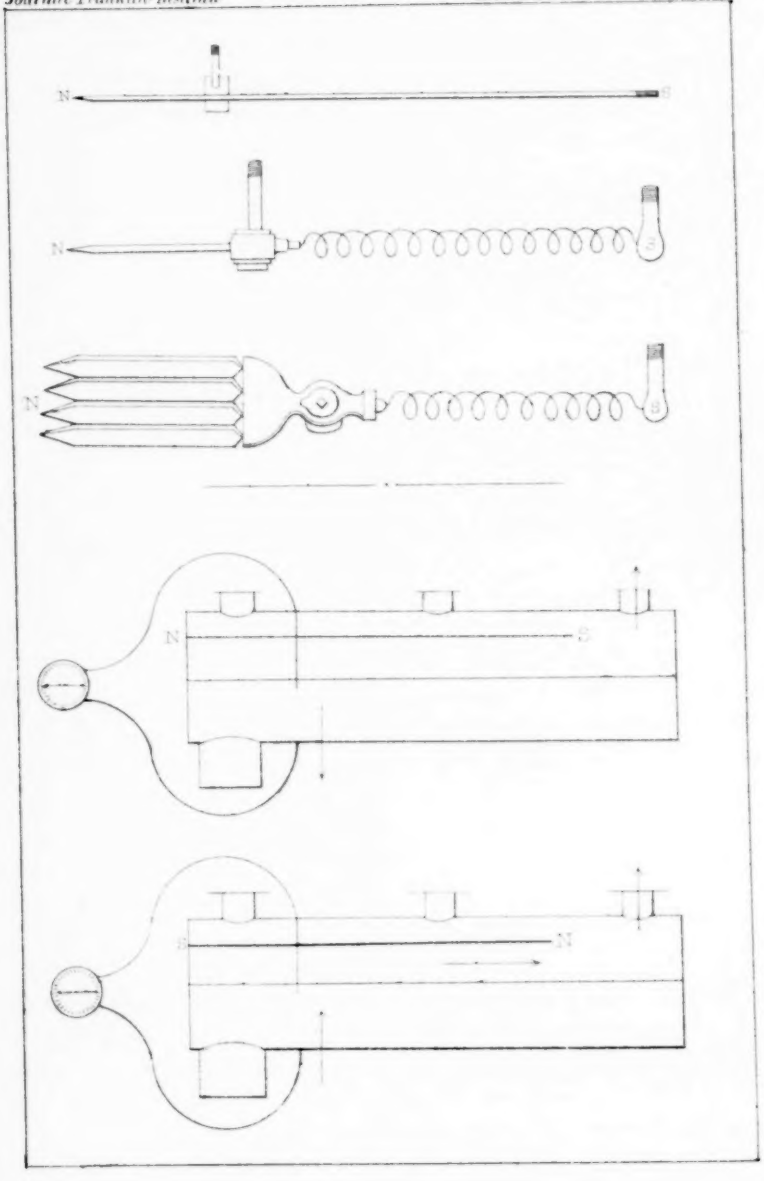
Denomination and Value.		Equivalent in English (Wine) Measure.
Kilolitre or Stere	1000 litres = 1 cubic metre	264·17 gallons.
Hectolitre	100 " = $\frac{1}{10}$ " "	26·417 "
Decalitre	10 " = 10 " decimetres	2·6417 "
LITRE	1 litre = 1 cubic decimetre	1·0567 quart.
Decilitre	$\frac{1}{10}$ " = $\frac{1}{10}$ " "	0·845 gill.
Centilitre	$\frac{1}{100}$ " = 10 cub. centim.	0·338 fluid oz.
Millilitre	$\frac{1}{1000}$ " = 1 " "	0·27 " drm.

Weights.

Denomination and Value.		Equivalents in English Avd. Weight.
Millier or tonneau	= 1,000,000 grms. = 1 cub. met. of W. @ 4° C.	= 2204·6 lbs.
Quintal	= 100,000 " = 1 hectolitre " " "	= 220·46 "
Myriagramme	= 10,000 " = 10 litres " " " "	= 22·046 "
Kilogramme or kilo	= 1000 " = 1 litre " " " "	= 2·2046 "
Hectogramme	= 100 " = 1 decilitre " " " "	= 3·5274 oz.
Decagramme	= 10 " = 10 cubic centim. " "	= 0·3527 "
GRAMME	= 1 " = 1 " " " "	= 15·43235 gs
Decigramme	= $\frac{1}{10}$ " = $\frac{1}{10}$ " " " "	= 0·5432 "
Centigramme	= $\frac{1}{100}$ " = 10 cub. millim. " "	= 0·1543 "
Milligramme	= $\frac{1}{1000}$ " = 1 " " " "	= 0·0154 "

Inch	= 25·39954	millimetres.
Foot	= 3·047945	decimetres.
Mile	= 1609·315	metres.
Square Inch	= 6·45·367	square centimetres.
" Foot	= 9·28997	" decimetres.
" Yard	= 83·60971	" "
" Acre	= ·4046711	of a hectare.
" Mile	= 258·9895	hectares.
Cubic Inch	= 16·38618	cubic centimetres.
" Foot	= 28·315312	" decimetres, or litres.
Gallon	= 4·54346	litres.
"	= 277·274	cubic inches.
Grain	= 64·79896	milligrammes.
Pound Avd.	= 453·5927	grammes.

(To be continued.)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RESULTS OF EXPERIMENTAL TRIALS OF THE AMERICAN ANTI-INCRUSTATOR.

By CHARLES M. CRESSON, M.D.

[THE subject of the American Anti-Incrustation is one of curious interest, as well as great practical importance. At its first appearance it had the unfortunate aspect of an absurdity or a humbug, having been linked to an explanation or theory, embodying most of the popular errors and confusions respecting the nature of electricity, which are current among the ignorant. Multiplied facts demonstrating practical efficiency, independent of theory, however, at last lead gentlemen of education and established scientific reputation, to take the matter in hand, and give it the support of their names and authority as witnesses of fact. Testimony of the strongest kind from many sources has thus been accumulated, as to the fact that, in a vast number of cases, the instrument *does* produce the effects claimed for it.

To the purely practical mind this may be sufficient, but to the generality of mankind a sensible want would be supplied, if a reasonable solution could be furnished to the natural question, How are these results produced? It is, therefore, with pleasure that we present to our readers the following communication, prepared by Dr. Charles M. Cresson, in response to a letter from James Harper, Esq., Managing Director American Anti-Incrustation Co., which we believe to be the first essay, of a thorough and scientific character, which has been made towards the solution of this new and curious problem.—ED.]

OFFICE AND LABORATORY,
Schuylkill Navigation Building, 417 Walnut St.,
Philadelphia, April 15th, 1867.

JAMES HARPER, Esq.,
Managing Director American Anti-Incrustation Co.

DEAR SIR:—In answer to yours of the 9th inst., I have prepared this condensed statement of the most prominent results of my examination of your instruments for the removal and prevention of scale in steam-boilers, with the deductions which seem to follow from the experiments.

In order to make the explanations of the principles involved more intelligible, I have prepared a few simple diagrams, exhibit-

ing to the eye the direction of the obscure currents produced by the conjunction of electrical and magnetic forces.

The apparatus furnished by the American Anti-Incrustation Company consists, in its simplest form, of a magnetic bar of hardened steel, suspended horizontally within the steam-boiler, in the upper part of the steam-space, the south pole of the bar connected with the shell of the boiler, and the north pole supported by an insulated hook.

If the magnetic bar be not of sufficient length to extend nearly throughout the horizontal steam-space, it may be prolonged by a rod or wire of metal, so as to connect the south pole with the boiler, care being taken to keep this wire insulated from immersion in the water, and from metallic contact with the boiler, except at its point of attachment to the shell.

In large boilers it is usual to place three or more bar-magnets side by side, with their south poles, secured to a block of metal, which block is connected with the shell of the boiler; and in very long boilers several instruments may be set at varying distances from the end of the boiler, all presenting the south pole to that end with which they are connected.

Experimental trials made upon the apparatus, and modifications of it, have elicited certain facts.

If we replace the magnet-bar by a bar of steel, without polarity, and employ a solution in the boiler which will deposit scale upon the application of heat, we find that the neutral bar gradually obtains polarity, and that the insulated end becomes a south pole; the deposit of scale then taking place with great rapidity.

With the magnet-bar properly placed, with its north pole insulated and its south pole connected with the boiler, the scale already formed is gradually removed, and any fresh deposit prevented.

During the performance of this work, the bar slowly loses its polarity, and if, at this time, it be not remagnetized, it will eventually assume the reverse polarity, and fail to prevent the formation of scale.

If, in placing the instrument within the boiler, we so arrange it that the outflowing steam shall pass along the bar in the direction from its south pole towards its north pole, then is its action increased; but if the outflowing steam pass it in a contrary direction, we may not only retard, but entirely prevent, the proper working of the instrument.

In order to determine the effect of the polarized bar upon the electrical currents in the water, insulated wires were passed through the outer shell of the boiler, and the exposed ends of the wires fixed at varying distances from the bottom surface inside. These wires were successively connected with one pole of a galvanometer, whilst to the other pole was connected a wire in metallic contact with the shell on the outside.

During the formation of scale, the electrical current was mostly passing from the water to the shell. Upon inserting the polarized bar in a proper position, the direction of this current was reversed and passed from the shell to the water.

In addition to the influence of the nearly constant passage of steam from the boiler, by the ordinary outlet, various temporary minor modifications of the thermo-electric currents are caused by the use of the blow-out and gauge-cocks, and by any check to the fires beneath the boilers—such as by the addition of fresh fuel. The general direction of the current is toward an outlet of the boiler; more especially such an one as may be conveying off water or wet steam.

The tendency of electrical and thermal currents to proceed in the same direction, renders it a matter of some importance to locate properly the general steam outlet and blow-outs, in reference to the furnace, so that the currents induced may not interfere with each other.

To assist in explaining the relations which heat, electricity, and magnetism bear to each other, and the modes of their conversion, I have selected the following principles, as announced by Faraday, Grove, Noad, and others, in their researches, togother with the illustrations of their action:—

"To obtain electricity from magnetism, it is necessary to superadd motion."

"Magnetism will produce electricity with the help of a dynamic force (heat)."

"Bodies affected by an electrical current, are definitely moved by a magnet in proximity to them; and so, conversely, bodies moved near a magnet, have an electrical current developed in them."

Faraday's illustration of these abstract principles is as follows:—

"A copper plate, mounted on an axis, is furnished with a handle for giving it motion; one wire, connected with a galvanometer, is retained in perfect metallic connection with the axis, and another, connected also to the galvanometer, is kept in contact with the cir-

cumference of the disk. A horse-shoe magnet is so placed as to embrace, with its poles, the disk and wire in contact with the circumference, but without touching them; the north pole of the magnet being towards the observer, and upon the left-hand side of the disk.

"When the machine is made to revolve from right to left, a current of electricity flows from the centre to the circumference of the disk. If the revolution of the disk, or poles of the magnet, be reversed, the direction of the electrical current is reversed also, and proceeds from the circumference to the centre of the disk. A similar effect can be produced by drawing a slip of metal between the poles of the magnet.

"So, also, when a plate of metal is made to rotate beneath a magnetic pole (suppose a north pole), a series of currents of electricity will pass from the centre to the circumference of the plate, if it is rotating in the direction of the hands of a watch; or, from the circumference to the centre, if it is rotating in the contrary direction."

This directive power, which the magnet possesses over electrical and thermal currents, explains why the magnetic force of the instrument, employed for removing incrustation from steam-boilers, should be diminished, and finally reversed, when the outflowing steam is compelled to pass it in a direction from its north pole to its south pole, and why the effect of the magnets is increased by the passage of steam in the contrary direction, or from its south pole to its north pole, as well as the occasion of the magnetic condition of the boilers of opposite polarity to that of the directing magnet, as the currents inducing it proceed from its upper surface.

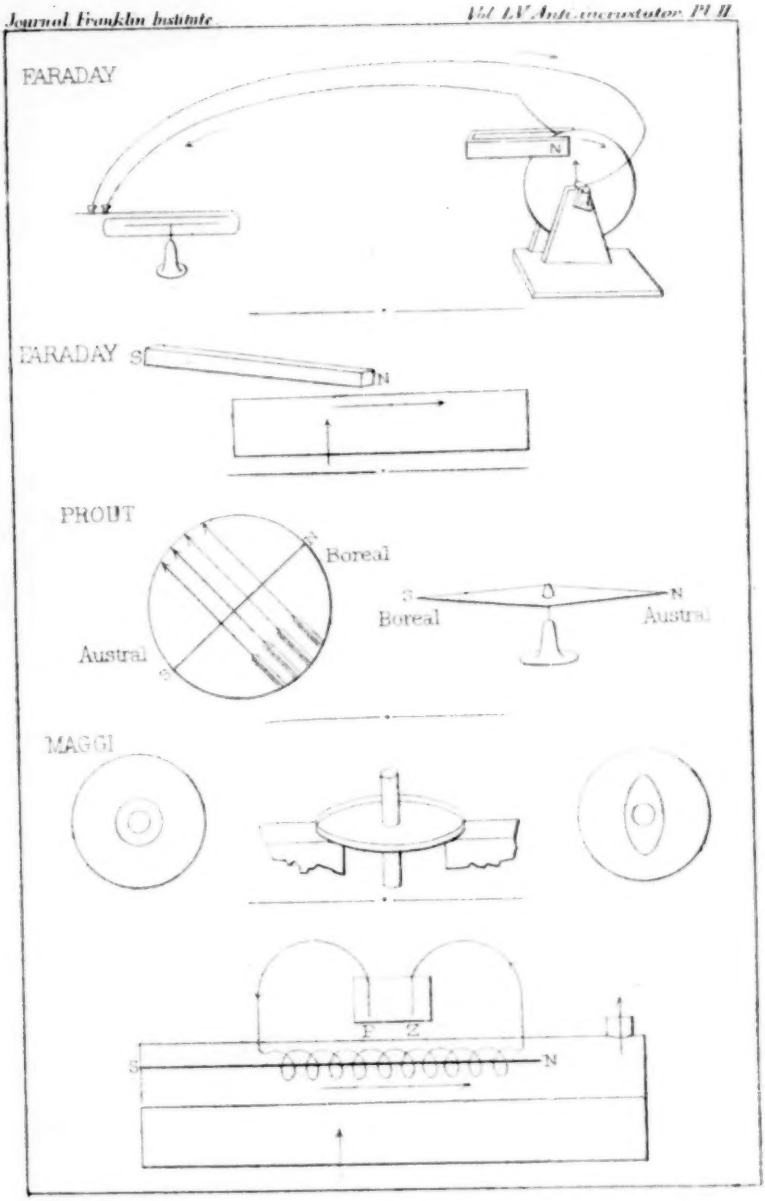
"An electric current appears to have a magnetic action in a direction cutting it at right-angles."

"Thermo-electricity connects heat with electricity, and consequently with magnetism."

To give an idea of the magnetic force, and its magnitude and direction, as developed by the action of apparently weak thermal currents, attention need only be directed to the earth itself. The earth is considered to be a great magnet, produced by electrical currents circulating around it.

Dr. Prout thus explains the causes of these electrical currents:—

"The earth, during its diurnal motion on its axis from west to east, has its surface successively exposed to the solar rays in an opposite direction, or from east to west. The surface of the earth, therefore, particularly between the tropics and in parallel zones, will be heated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and cooled in succession from east to west, and currents of electricity, on thermo-electric principles, will, at the same time, be established in the same direction. Now, these currents thus established, from east to west, give rise to the magnetism of the earth from north to south; hence the magnetic directive power of the earth, in a direction nearly parallel with its axis, is derivable from the thermo-electric currents, induced principally by its diurnal motion.

"When substances are undergoing chemical changes, and a magnet is brought near to them, the direction or lines of action of the chemical force will be changed. In these cases there is not a *production* of light, heat, or chemical affinity by magnetism, but a *change* in their *direction* or mode of action."

In illustration of this principle, Prof. Groves gives Dr. Maggi's experiment, exhibiting a change in the direction of thermal conduction under the influence of magnetic polarity:—

Cover a plate of homogeneous soft iron with a thin coating of wax, mixed with oil—a tube traversing the centre, through which the vapor of boiling water is passed, the plate to rest on the poles of an electro-magnet, with card interposed. When the iron is not magnetized, the melted wax assumes a circular form, the tube occupying the centre; but when the electro-magnet is put in action, the curve, marking the boundary of the melted substance, changes its form and becomes elongated in a direction transverse to the line joining the poles, showing that the conducting power of the iron for heat is changed by the magnetism.

From an examination of the principles above expressed and illustrated, in combination with other well-known laws, the following conclusions are reached:—

First.—In a steam-boiler, the thermal, and consequently the electrical currents, flow alternately towards and from the heated shell, as induced by variations of the temperature of the different parts of the shell and water, until some great disturbance of electrical tension is made by taking off steam or water rapidly; when, in order to restore the equilibrium of tension, electrical currents near to the shell of the boiler flow constantly to it—as the metal is a better conductor of electricity than water—carrying with them any matter that may be in solution or in suspension, and thus cause formation of scale in compact columnar form.

Second.—The thermo-electrical currents can be controlled by a suitable magnetic force; and therefore the magnets used in the

American Anti-Incrustation Company direct the lines of thermo-electric action, and in this way remove or enfeeble the causes of the compact deposition of bodies in solution or suspension in the water in the boiler.

Third.—Where scale has already been formed previous to the application of the instrument, it is repelled by the agency of magnetic and dia-magnetic forces, exerted in consequence of the polarity of the shell of the boiler, induced by the movement of the thermo-electric currents, directed or governed by the magnetic bar of the instrument; which repulsion favors the intrusion of a minute film of water between the iron of the boiler and the scale, and the latter is loosened and broken up by the expansion of the watery film into steam.

A further proof of the correctness of these assumptions, is found in the fact that, by exalting the intensity of magnetic action, by the substitution of a powerful electro-magnet in place of the weaker permanent magnets commonly used, the effects of deposition and removal of scale, as already described, take place with such increased rapidity as to produce, in a few hours, results which, with the ordinary apparatus, have required many weeks or months.

The introduction of metals in the water of the boiler, which are electro-negative or electro-positive to the metal in the shell (copper or zinc), either tend to corrode the boiler, or to oppose the action of the instruments.

In the whole course of these experiments there has been no evidence of the production of any galvanic action having the slightest tendency to oxidize, or in any way to injure the metal of the boiler.

Respectfully,

CHARLES M. CRESSON.

FLAME REACTIONS.

BY PROF. BUNSEN.

Translated by Prof. Charles F. Himes, Ph.D., Dickinson College, Carlisle, Pa

(Continued from page 54.)

THE following are the incrustations that can be produced:—

a. Metallic incrustations are obtained by placing a particle of the specimen on an asbestus fibre, in the upper not too large reducing

flame, with one hand, whilst with the other hand a very thin externally glazed porcelain capsule, 1 to 1·2 decimetres in diameter, filled with cold water, is held immediately over the asbestus fibre, in the upper reducing flame. The metals separate as coal black, dull, or shining incrustations and coatings. Even lead, tin, cadmium, and zinc give, reduced in this way, metallic coatings, which cannot be distinguished, by their appearance simply, from the blackening produced on porcelain by carbon. These incrustations, when treated, by the aid of a glass rod, with drops of dilute nitric acid, containing about twenty per cent. of anhydrous acid, manifest different degrees of ease of solubility, which may serve for their recognition.

b. Incrustation of oxide is produced by holding a porcelain capsule, filled with cold water, in the *upper oxidizing flame*, and proceeding in the same direction as for the production of a metallic incrustation. If but a small particle of the substance is employed for the test, the lamp-flame must be proportionally diminished, so that the products of volatilization do not spread too much over the porcelain surface.

The incrustation of oxide is tested in the following manner:—

b'. Its color is noticed as well as that of the coating.

b''. It must be determined whether a drop of proto-chloride of tin effects a reduction.

b'''. If no reduction takes place, caustic soda is added to the proto-chloride of tin until the precipitated hydrated protoxide of tin is dissolved, and it is noticed whether a reduction then takes place.

b''''. A drop of perfectly neutral hydrate of silver is spread, by means of a glass rod, upon the incrustation, and a stream of ammoniacal air blown upon it by means of a small wash-bottle, containing solution of ammonia, in which the mouth-tube dips beneath the liquid, and the exit-tube only extends below the cork. If a precipitate occurs, its color must be noticed, and also whether it dissolves, or what changes it may otherwise suffer when treated with a current of ammoniacal air for some time, or when solution of ammonia is dropped upon it.

c. Incrustation of iodide. This is formed in a simple way, out of the incrustation of oxide, by breathing upon the cooled capsule upon which the latter is found, and placing it upon the wide-mouthed, accurately stoppered glass vessel, Fig. 8, which contains iodide of phosphorous converted by deliquescence into fuming hydriodic and phosphorous acids. If the mixture ceases to fume by reason of ab-

sorption of water, it is only necessary to add some anhydrous phosphoric acid to render it fuming again. Heavier incrustations, often consisting of a mixture of iodide and subiodide, and therefore less uniform, can be produced by fuming the incrustations of oxide by means of a concentrated solution of iodine in alcohol, which is passed whilst burning, by means of a bunch of asbestus fastened to a platinum wire, back and forth under the capsule, still filled with cold water. If some dilute hydriodic acid, rendered brown by iodine, also condenses at the same time upon the capsule, it is volatilized by *gently* warming and blowing upon it.

Fig. 8.

The testing of the incrustation consists in the following:—

c'. Its solubility is tested simply by breathing upon it as soon as the capsule has become cold, whereupon its color changes or disappears entirely as it dissolves in the moisture of the breath. If the capsule is gently warmed, or blown upon at a short distance, the incrustation, dried by the current of air, reappears unchanged.

c''. The ammonia compound of the iodide, is formed by blowing upon the latter ammoniacal air, and noticing thereby whether the color of the incrustation and coating disappears rapidly or slowly or not at all, or whether changes of color are produced. The different coloration reappears instantly, if the capsule is placed for a few moments upon the mouth of a vessel containing fuming hydrochloric acid.

c'''. The incrustation of iodide also usually gives, with nitrate of silver and ammonia, as well as the proto-chloride of tin and hydrate of soda, the same reactions as the incrustation of oxide.

d. Incrustation of sulphide is most easily produced from the incrustation of iodide, by blowing upon it a current of air containing sulphide of ammonium, and removing the excess of sulphide of ammonium by *gently* warming the porcelain. It is advisable, whilst blowing upon it, to breathe from time to time upon the forming incrustation of sulphide. The following experiments are to be made with the incrustation:—

d'. By breathing upon it or dropping water upon it, it is determined whether it is soluble. The incrustations of sulphide often have precisely the same color as the corresponding incrustation of iodide, in which case they can generally be distinguished from the latter, by their insolubility when breathed upon.

d''. The solubility of the sulphide in sulphide of ammonium is tested by blowing or dropping it upon the incrustation.

4. *Incrustations on test-tubes.* Under some circumstances, it is advantageous to collect the incrustation from reduction upon the lower part of a large test-tube half filled with water, Fig. 5, D, especially when it is desirable to accumulate a considerable quantity of the reduction incrustation for further experiments. The fine asbestus fibre, with the test-specimen adhering to it, Fig. 5, *d*, is fixed, by means of the glass tube, *b*, as a support, before the lamp, as high as the middle of the upper reducing flame; the test-tube is then placed, by means of the movable support, B, Fig. 5, so that the bottom may be immediately over the asbestus fibre. By shoving the lamp under the test-tube, then, the asbestus fibre, with the test-specimen, will be found in the reducing flame.

According to the length of the time the apparatus is allowed to remain in this position, during which the test-specimen on the asbestus fibre is necessarily renewed, deposits of any desired thickness can be obtained. Since the water soon begins to boil, a few pieces of marble are placed with it in the test-tube to prevent violent ebullition.

III.—Reactions of Substances.

Substances immediately recognizable by the flame reactions are divided most advantageously according to their behaviour upon oxidation and reduction into the following groups and subgroups:—

A. Substances reducible to metal, volatile, separable as incrustations.

1. Incrustations scarcely soluble in cold dilute nitric acid*—Tellurium, selenium, antimony, arsenic.

2. Incrustations slowly and difficultly soluble in cold dilute nitric acid—Bismuth, quicksilver, thallium.

3. Incrustations instantly soluble in cold dilute nitric acid—Cadmium, zinc, indium.

B. Metals that do not give incrustations, but are separated in the regular form.

1. Not fusible to globules upon reduction—*a*. Magnetic iron, nickel, cobalt. *b*. Non-magnetic palladium, platinum, rhodium, iridium.

2. Fusible to globules upon reduction—Copper, tin, silver, gold.

* Containing twenty per cent. anhydrous acid.

c. Substances separable and recognizable most easy as compounds—Tungsten, titanium, tantalum and niobium; silicon, chromium, vanadium, manganese, uranium, sulphur, phosphorous.

I will now give the special reactions of the substances arranged in these groups.

(To be continued.)

EDUCATIONAL

THE MAGNESIUM LAMP.

By Albert R. Leeds.

For some time after I had received a Magnesium Lamp from the American Magnesium Company, I was deterred by irregularities in its performance from bringing it into frequent use. The blade of the key had been forced between the springs which clip the axle of the fan-wheel broadside, by some one unacquainted with the lamp, instead of edgewise, and the springs had thus become so far impaired as not to arrest the motion promptly. I have now, however, properly adjusted them, and find the starting and stopping of the lamp to be perfectly under control. Some difficulties still remain. In one instance, a piece of unburnt ribbon became jammed between the knife-edges of the wheels which remove the ashes, and arrested the clock. The lamp may go out from some unknown cause, a powerful draft in the chimney perhaps, or an imperfection in the material of the ribbon, or perchance a too rapid combustion. These difficulties are vanishing one after another, by perseverance in the use of the instrument; and even with the drawbacks mentioned above, I find the lamp to come more frequently and advantageously into use, in delivering courses of popular lectures on natural philosophy and chemistry, than any other piece of apparatus.

Many experiments of much scientific value fail to excite the interest expected by the lecturer on account of an utter inability in the hearers to see what is taking place—as, for example, the Mercurial Rain. But if a black cloth be hung upon the back of the

receiver, and the lamp be turned towards it, the falling of the brilliantly illuminated spheres of mercury through the vacuum, becomes a striking spectacle. So, also, if it be desired to show that the expansion of the air in a receiver placed upon the plate of an air-pump, absorbs sufficient heat to condense the vapor, the opening of the lamp may be placed almost in contact with the sides of the vessel and the powerful cone of diverging rays thus obtained will show the clouds in the receiver rising and falling, and lit up with the prismatic colors. Or, by allowing the air previously compressed into a condensing chamber to escape freely into the atmosphere, its course will be traced by the rays of the lamp as a cone of vapor. No thermo-electric pile is requisite for the exhibition of this valuable experiment upon the absorption of heat.

When the lamp has been used for some time without the flexible chimney, a considerable amount of magnesia becomes diffused through the room, which serves to mark out in a striking manner the rectilinear course of rays of light,—diverging and converging cones,—the focussing of rays taken from the outer portions of lenses, the different positions of foci, the reflection of light from plane surfaces and from spherical and parabolic mirrors. It happens not unfrequently that the employment of the lantern for a few moments would be desirable, in order to learn whether a lantern illustration which it is intended to use, would be a satisfactory one, or perhaps the lantern would be useful for a short time in a lecture. If it is necessary to consume all the time and material requisite to prepare the mixed gases, the experiment goes untried. The subject of capillarity, for example, might be alluded to, and it would be desirable to show that the level of a liquid is elevated between two plates—the very nature of the action prevents it from becoming visible except on close examination. On the contrary, when set in the lantern, the equilateral hyperbola may be exhibited in faultless symmetry of form, as a curve of 20 feet or more in length; or, if it be desired to exhibit upon the screen the expansion of water in a thermometer bulb, when the temperature has fallen below 39° F., or the convection of heat by the rising of colored liquid from the bottom of a glass tank under the action of a coil of platinum wire heated by a galvanic current—one of Prof. Morton's beautiful experiments—or the electrolysis of water, salt, iodide of potassium, etc.; for all these purposes the occasional use of the Magnesium Lamp is invaluable. It is a great saving of trouble, and adds very much to the interest of

a lecture to put a photographic etching, or an Indian ink drawing into the lantern, instead of preparing a large diagram, which, after all, is less visible. Less trouble, I mean, when no pressures are to be arranged, no lime cylinder to be put into position, and no waiting for air to blow out of tubes.

It is desirable sometimes to set the lantern in unusual positions, far back in a room where press-boards could not be conveniently arranged, or near the ceiling, as in the experiment of the Total Reflection of Light in a Liquid Vein, in either case requiring unusual connections and increased length of tubing. All this trouble is obviated by the Magnesium Lamp.

The ease with which the light is focussed, as compared with that from the lime cylinder, is another feature of practical advantage. I have three lanterns, into any one of which I place the lamp, adjusting its level by a block of wood or book and a piece of card-board with surprising facility. The lantern-box, indeed, is not necessary. A strip of wood on which to place the lamp, and carrying one upright piece for the condensers and another movable upright for the object-glass, is a better arrangement. A hood prevents escape of stray light. At some leisure moment, I shall try the Magnesium Lamp in the Polariscope to determine whether its illumination is sufficiently strong and steady to give satisfactory results.

WHAT IS CIVIL ENGINEERING? WHAT, A CIVIL ENGINEER? AND WHAT, THEREFORE, MUST A PROFESSOR OF CIVIL ENGINEERING BE?

(Continued from vol. liv., page 423.)

[NOTE.—In consequence of an unauthorized liberty taken by our printer, in arranging his matter according to physical principles of extension and figure, in place of the literary laws of meaning and continuity, Professor Warren's article appeared in our Dec. number mutilated in a manner which occasioned us the greatest mortification. A portion of the title was cut out and half the last paragraph was omitted, without even a "To be continued" being inserted. This was done after the proof had been duly corrected, and thus escaped our notice until the number was in circulation. For the encouragement of our contributors we may state, that though (from its very unprecedented character) such a performance might occur once it cannot happen twice.—EDITOR.]

IV. *Professor of Descriptive Geometry and Stereotomy*, the latter being comprehensively the art of shaping the component members of a proposed structure to their intended places, and of shaping forms

generally, to fulfill given conditions, as in the construction of *shadows* corresponding to different bodies and circumstances of illumination; the construction of *perspectives*, agreeing with different conditions of form, distance, and direction in the object represented; *stone-cutting;* and the shaping of mechanical members to produce certain motions; or *cinematics.*

V. *Professor of Geodesy and Engineering Astronomy.*

VI. *Professor of Experimental Physics.*

b. Auxiliary or Collateral Professorships, resident or non-resident teaching by book or lecture, and with or without daily interrogation.

I. *Professor of Chemistry and Mineralogy.*

II. *Professor of Natural History, Geology, and Physical Geography* (in charge of practical meteorology).

III. *Professor of Modern* (foreign) *Languages.*

IV. *Professor of English Language and Literature* (non-resident lecturer).

V. *Professor of Mental and Moral Philosophy and Aesthetics* (non-resident lecturer).

VI. *Professor of Engineering Law and Political Economy* (non-resident lecturer).

VII. *Professor of Free Drawing and Modelling.*

VIII. *Professor of Anatomy and Physiology and Physical Culture.*

Thus we see, that, so far from its being possible for a single individual to be duly a "professor of civil engineering," a faculty of engineering should embrace no less than six fundamental professorships, and that the main body alone of engineering science, to which all its other parts are tributary, viz: mechanics, affords matter for two professorships.

We merely add in passing, that the subordinate character of the second group of professorships is, of course, not absolute, but relative, in connection with engineering construction, exclusive of mining engineering. In a school of mines, and in other institutions, those departments which are secondary here, would be primary, and even divisible, like mechanics in the present case, among two or more professors.

Hoping now that these views have been so acceptably explained to commend them to sound reason, and thus, so as to promote the just observance of true principles in the organization of schools

for engineers and other professional technists in this land, we contribute them in behalf of the real, because well-grounded, success of these schools, which, indeed, are being more and more cherished both by the scientific, and the enlightened popular mind of the nation.

Troy, September, 1867.

CIVIL ENGINEERING.

ITS SCOPE AND AIM, AND THE PROFESSORSHIP OF IT.

By S. Edward Warren, C. E.,
Professor of Descriptive Geometry, etc., Rens. Pol. Institute, Troy, N. Y.

Civilization is both the recognition and the realization of individual good, in and through the general good; as well as the general good, in the sum of individual good.

The *recognition*, alone, is *potential* civilization; *subjective*, or in the mind of the thinker.

The *realization*, alone, is *actual* civilization.

The full recognition and realization united, and by all, constitutes complete and perfect civilization.

War, on the contrary, is an agency for securing certain real or supposed good to some, by nothing less than the utter destruction of others.

While, therefore, war is the physical expression of the conflict of ideas and purposes, and the extreme form of the convulsions incident to the mighty transformation of humanity from a state of barbarism to that of civilization, yet, in proportion as civilization is actually attained, appreciated and loved, is war deplored, and resorted to only to defend existing civilization from fearful damage, or positive loss.

No opposites, therefore, can be more strongly contrasted than are war and finished civilization.

These preliminary principles are of service in defining civil engineering, both separately, and by exhibiting it against the background of an idea of totally different hue.

Civil engineering, then, is the determinate application of the laws of matter, form, and force, in the direction and disposition of matter, and the employment of forces, favorably to civilization.

And again, civil engineering is that which is opposed to military

engineering, inasmuch as the latter contemplates the destruction of existing material fruits of civilization, even though it be only the destruction of a part in order to save the rest.

Civil engineering is only, in spirit and purpose, *constructive*. Military engineering is principally *destructive*, and at best only conservative.

So much being now secured in general terms, we bring to bear upon our thoughts the remembrance of the breadth, and depth, and multiformity, and complexity of present civilization, and the consequently limited portion of its wants to which any one agent can thoroughly minister. We are then led to seek out a suitable number of real and co-ordinate divisions of civil engineering, each of which shall he broad enough to constitute a field for life-long professional practice.

These would seem to be—

Road Engineering, embracing the reconnoissance, survey, location, calculation, construction and maintenance of steam and common roads, with the design, involving mathematical investigations, and the erection, of all their auxiliaries and accompaniments, viz: wood, stone, and iron bridges in all the different systems of each, tunnels, retaining walls, etc.

Hydraulic Engineering, embracing the like particulars, relative to canals, water-works, town and city sewerage, and drainage generally, river and harbor improvements, and works for irrigation.

Mechanical Engineering, embracing the design, erection and superintendence of water, wind, steam, or other motors, and of mills, mill work and machines generally.

Topographical Engineering, embracing the conduct of those higher operations of geodesy, engineering astronomy, and the incident elevated computations; in which the sphericity of the earth is regarded; and a higher, and, in part, a different class of instruments is employed from what is necessary in the previous departments.

Mining Engineering, embracing geological surveys, and the exploitation, survey, opening and superintendence of mines; and the design, erection and management of works for the reduction of mining products.

In a former article (see the December number of this *Journal*), we contemplated civil engineering on its scholastic or educational side, and saw the impossibility of any one person's teaching all that immediately constitutes a knowledge of it.

We now contemplate the same subject on its practical or executive side, and plainly see that the engineer's solution of the numerous great and varied problems of his profession, cannot properly be empirical, a mere blind following of rules deduced for him by geometers and analysts, or a blind experimental groping after a lucky result.

His work is the determinate and intelligent application of the laws of matter, form, and force to the accomplishment of his purposes.

He must therefore understand the laws of matter, the properties of form, and the doctrines of force. All these are capable of exact quantitative expression, agreeably to definite given conditions; and mathematics, as the science of quantity, furnishes the means for their expression. Moreover, as the action of forces may be endlessly varied by the imposition of various conditions, the *science of mechanics*, which discusses their action, both absolutely, and as acting in and through matter, and modified by the properties of matter, is a *subject of indefinite extent.* Also, as the problems of forces are often very complex, from the number and character of the conditions under which the forces act, the science of mechanics is not only of vast extent, but of great profundity, requiring the best service that pure mathematics can bring to its aid.

We dwell a moment longer on this point—the magnitude of the science of mechanics; because, in view of the scanty instruction on the subject in ordinary American collegiate education, together with the absence, in this country, until recently, of well-developed *professional* schools of technical science, it is probable that it is precisely on this point that the greatest popular misapprehension prevails among the great body of merely college men. And yet a just apprehension of the magnitude of the subject of mechanics is most vital to a true apprehension of the range and scope of engineering study and qualification.

But what can we say? To transcribe the table of contents of really elevated works on rational and technical mechanics, would afford little real information. We must then adopt the method of simply referring to examples, such as the works of Bartlett, Pierce, Weisbach, Mosely, Rankine, and the prominent French writers; to the programme of over eighty lectures on the subject, in the Polytechnic School at Paris, based on requirements in mathematics and mechanics, for admission, which it would require a very respectable mathe-

matician to fulfill; and, finally, to the almost continuous study of this subject and its applications, *mathematically treated*, for a year and a half, in our oldest American scientific school.

With this final reference to examples, added to the previous reflections, may we not innocently, nay, more, usefully say, that the acceptance of the nomenclature "professorship of civil engineering" as *logically fit*, I mean, rather than *provisionally expedient* only, comes to just this: it is a test of the standards of thought prevailing at any given time and place, as to what civil engineering knowledge really is; and, consequently, of the real standard of instruction in it, actually adopted.

We say this in admiring view of what able and devoted American pioneers, concentrating their efforts on small classes, have been able to accomplish in teaching many of the components of engineering knowledge; but, in turning from the imperfectly developed actual to the ideal, now fairly attainable in more places than one, we declare the nomenclature alluded to to be a mainly unintelligible misnomer; and earnestly hope that the uprising company of schools of science based on the national land grants, and all others, also, will reject it, and designate the several *essential* members of a proper *faculty of engineering*, by the component subjects which they teach, and each of which subjects, taught as fully and as faithfully to the student, as a due standard of engineering education demands, is abundant to duly fill one professor's time.

In our former article, mention was made of several possible meanings which might attach to the words "professorships of civil engineering." Thus, a long course of instruction could be given, purely descriptive of the practical expedients adopted, and operations conducted, in the actual erection of engineering structures from foundation to coping stone. But such a course, though invaluable, if only to bring the student-mind into contact with fresh engineering practice, would be but a fragment of the total of engineering tuition. Yet, for the five broad divisions of civil engineering already described, it would well fill one instructor's time.

On the lowest legitimate view, a professorship of civil engineering should embrace the analytical investigation of the strains on each of the members of every important species of engineering structure; in other words, the application of pure, or rational mechanics, to the determination of the principles of the stability of structures.

But even this knowledge, added to that of the means and methods

of constructive practice, is not all that it is *essential for an engineer to know.* Wherefore, these last words are those on which the whole question turns; and we feel free to adhere to the broader view, and to announce it as a demonstrated proposition, that any officer of instruction, in a school for professional scientific training, who teaches anything *which it is essential for an engineer to know*, is, to that extent, a "professor of civil engineering," and a member of a duly constituted faculty of engineering.

In now dismissing the subject for the present at least, we have only to add, that in discussing it, we hope we have expressed no unjust or unwelcome thought.

Rens. Pol. Inst., Nov. 1867.

Franklin Institute.

Proceedings of the Stated Monthly Meeting, December 18th, 1867.

THE meeting was called to order with the President, Mr. J. Vaughan Merrick, in the chair.

The minutes of the last meeting were read and approved.

The Actuary submitted the minutes of the Board of Managers, with the following abstract of the proceedings at their stated meeting, held December 11th, 1867.

The special committee appointed to prepare resolutions to be presented at the next stated meeting of the Institute for adoption, in reference to the death of Prof. Faraday, reported the following preamble and resolutions, viz:—

Whereas, Formal notification having been received by the Franklin Institute, from the Royal Society, of the decease of Professor M. Faraday, it seems appropriate to the Board of Managers that the following resolution should be offered to the Institute at its stated meeting:—

Resolved, That the Institute recognizes in the death of Professor Faraday a serious loss to the progress of science, which owes so much in various departments to his genius and industry.

Resolved, That the name of Professor Faraday should be cherished and honored as second to none of those which have adorned the annals of science.

Resolved, That a copy of these resolutions shall be officially transmitted to the Royal Society of Great Britain.

On motion it was

Resolved, That it is expedient that an exhibition of American Arts and Manufactures should be held during the year 1868 in the city of Philadelphia by the Franklin Institute, and that the President be requested to appoint a special committee to take the subject into consideration, and report at the next meeting of the Board with reference to obtaining suitable accommodation therefor, and an appropriate plan of action to be pursued.

The resignation of membership in the Board by Messrs. E. Y. Townsend, Charles H. Crump, and John Rice were accepted.

Donations to the Library were received from the Institute of Actuaries and Society of Arts, London; Commodore F. A. Jenkins, U. S. N., Chief of the Bureau of Navigation; Frederick Emerick, Esq., Washington, D. C.; Stephen P. Sharpless, Esq., Cambridge, Mass.; Messrs. Joel Giles, Josiah Copley, R. S. Menamin, Edward Shippen, and Chas. Macdonald Philadelphia.

The various Standing Committees reported their minutes, and the Committee on Experiments in Steam Expansion reported progress.

A paper by Mr. Thos. Dunn, on the Construction of Iron Bridges without Scaffolding, was then read by the Secretary. The Secretary's Report on Novelties in Science and the Mechanic Arts was read.

The following nominations of candidates for officers for the ensuing year were then made:—

For President, J. Vaughan Merrick; Vice-President, Professor Robert E. Rogers; Treasurer, Mr. Frederick Fraley; Secretary, Professor Henry Morton; Auditor, Mr. William Biddle; Board of Managers, William B. Le Van, Percival Roberts, Jacob Naylor, Alex. Ervine, Samuel Sartain, Henry A. Bower, O. H. Wilson, Robert H. Long, Charles Bullock, J. H. Lenville, E. Longstreth, W. B. Wilstach, Enoch Lewis, R. A. Tilghman, Jacob G. Neafie, Barton M. Jenks.

The President then appointed the following gentlemen as Judges of Election: William A. Rolin, C. S. Bement, Samuel Hart, Hector Orr, M. C. Haines.

The meeting was then, on motion, adjourned.

HENRY MORTON, *Secretary.*

Bibliographical Notice.

Lessons in Elementary Chemistry, Inorganic and Organic. By Henry G. Roscoe, B. A., F. R. S., Professor of Chemistry in Owens College, Manchester. London: Macmillan & Co.

A book, poor in typography, and with mean woodcuts, the latter being the worst specimens of engravings that we have ever seen. It is not written in such a manner as to attract beginners in the science of chemistry, much that is technical being introduced, to the exclusion of the details concerning experiments with oxygen, hydrogen, etc., which usually and very properly find their place in an elementary treatise.

Williamson's Chemistry for Students is a work deserving of high praise. The woodcuts, without being specimens of art, are clean and striking, while the general appearance of the printed page is very pleasing. It is especially valuable for its clear enunciation of the principles of modern chemistry, and for their consistent application to chemical problems and formulæ. The subjects of specific heat, heat of combination, the effects of pressure upon boiling-points, etc., are succinctly stated, and numerical examples given. Appended to the first twenty chapters are a skillfully framed series of problems, which are well calculated to familiarize the student with the metric system of weights and measures, the use of centigrade degrees, the calculation of vapor volumes at different temperatures and pressures, &c. The book is amply deserving of long-continued study, as being sufficient to place the student fairly upon the field wherein the labors of chemists of the present day are to be performed. We might suggest, that the process given for the manufacture of oxygen would almost inevitably burst the retort, and that the paragraph upon ozone is exceptional in falling behind our present knowledge of the subject. Although the arrangement of the chapters does not appear to us to be the one best adapted to their wants, yet it gives us great pleasure to recommend the work to *advanced* students of chemistry.

A COMPARISON *of some of the Meteorological Phenomena of* DECEMBER, 1867, *with those of* DECEMBER, 1866, *and of the same month for* SEVENTEEN *years, at Philadelphia, Pa.* Barometer 60 feet above mean tide in the Delaware River. Latitude 39° 57½′ N.; Longitude 75° 11½′ W. from Greenwich. By PROFESSOR J. A. KIRKPATRICK, of the Central High School.

	December, 1867.	December, 1866.	December, for 17 years.
Thermometer—Highest—degree	52·50	61·00	71·00
" date	27th.	8th.	2d, '59.
Warmest day—mean	47·33	57·00	62·80
" " date	28th.	8th.	2d, '59.
Lowest—degree	8·00	6·00	4·50
" date	12th & 14th.	21st.	19th, '56.
Coldest day—mean	14·17	15 33	11·00
" " date	13th.	21st.	18th, '56.
Mean daily oscillation	11·84	12·10	12·09
" " range	6·16	6·83	6·48
Means at 7 A. M.	29·26	31·58	31·84
" 2 P. M.	34·13	37·18	38 88
" 9 P. M.	31·77	34·19	34·62
" for the month	31·72	34·32	35·11
Barometer—Highest—inches	30 558	.....	30·678
" date	19th.	.....	18th, '56.
Greatest mean daily pressure	30·516	.....	30·611
" " " date	19th.	.....	18th, '56.
Lowest—inches	29·548	.....	28·946
" date	6th.	.....	9th, '55.
Least mean daily pressure	29·704	.....	29·175
" " " date	17th.	.....	9th, '54.
Mean daily range	0·256	.....	0·217
Means at 7 A. M	30 038	.....	29·955
" 2 P. M	30·027	.....	29·914
" 9 P. M	30·032	.....	29·942
" for the month	30·032	.....	29·937
Force of Vapor—Greatest—inches	0·361	0·472	0·551
" date	27th.	8th.	2d, '59.
Least—inches	·055	·042	·025
" date	13th.	20th.	18th, '56.
Means at 7 A. M	·133	·152	·145
" 2 P. M	·131	·153	·165
" 9 P. M	·146	·165	·157
" for the month	·137	·157	·156
Relative Humidity—Greatest—per cent	93·0	96·0	100·0
" date	12th & 27th.	16th.	Often.
Least—per cent	41·0	35·0	23·0
" date	29th.	9th.	15th, '61.
Means at 7 A. M.	78·5	79·4	77·6
" 2 P. M.	65·1	64·5	65·2
" 9 P. M.	77·1	76·9	75·3
" for the month	73·6	73·6	72·7
Clouds—Number of clear days*	5·	14·	8·6
" cloudy days	26·	17·	22·4
Means of sky covered at 7 A. M	72·9 per ct	46·4 per ct	64·1 per ct
" " " 2 P. M	70·6	56·4	63·7
" " " 9 P. M	52·6	42·6	49 0
" " for the month	65·4	48·5	58·9
Rain and melted snow—Amount—inches	2·860	3·522	3·765
No. of days on which rain or snow fell	12.	9·	10·6
Prevailing Winds—Times in 1000	N52°46′w·201	N78°16′w·351	N68°24′w·268

* Sky one-third or less covered at the hours of observation.

A COMPARISON *of some of the Meteorological Phenomena of the year* 1867, *with those of* 1866, *and of the last* SIXTEEN *years, at Philadelphia, Pa.* Barometer 60 feet above mean tide in the Delaware River. Latitude 39° 57¼′ N.; Longitude 75° 11¼′ W. from Greenwich. By PROF. J. A. KIRKPATRICK, A. M., of the Central High School.

	1867.	1866.	16 years.
Thermometer—Highest—degree.	91·00	101 00	101·00
" date.	July 4.	July 17.	July 17, '66
Warmest day—mean.	85·67	92·33	92 33
" " date	July 4.	July 17.	July 17, '66.
Lowest—degree.	8·00	—9·00	—9 00
" date.	Dec. 12 & 14.	Jan. 8.	Jan. 8, '66.
Coldest day—mean	14·17	2 67	—1·00
" " date	Dec. 13.	Jan. 8.	Jan. 9, '56.
Mean daily oscillation	14·48	13·91	14 77
" " range	5·30	5·80	5·53
Means at 7 A. M.	49·27	50·67	49·94
" 2 P. M	58·17	60 62	59 82
" 9 P. M	52·78	54·00	53·31
" for the year	53·41	54·90	54·36
Barometer—Highest—inches	30 970	30·757	30 970
" date	Feb. 11.	Jan. 8.	Feb. 11, '67.
Greatest mean daily pressure	30·862	30·665	30 862
" " " date	Feb. 11.	Jan. 8.	Feb. 11, '67.
Lowest—inches	28·778	28·820	28·778
" date	May 8.	April 23.	May, 8, '67.
Least mean daily pressure.	29·013	29,051	28·958
" " " date	May 8.	April 23.	Ap'l 21, '52.
Mean daily range	0·187	0·50	0·157
Means at 7 A. M	29 996	29·860	29·885
" 2 P. M	29·962	29 809	29 844
" 9 P. M	29·977	29·842	29·871
" for the year	29·978	29·837	29·866
Force of Vapor—Greatest—inches	0·925	0·980	1·059
" date.	July 6.	July 17.	June 30, '55.
Least—inches	0·42	·024	·013
" date	Jan., 30.	Jan. 8.	Feb. 6, '55.
Means at 7 A. M	·316	·331	·324
" 2 P. M	·325	·342	·339
" 9 P. M	·341	·361	·346
" for the year	·327	·345	·336
Relative Humidity—Greatest—per cent	100·0	100·0	100·0
" date	Oct. 29.	Jan. 15.	Often.
Least—per cent	21·0	18·0	13·0
" date	Apr. 6.	April 29.	Ap'l 13, '52.
Means at 7 A. M	75·6	74·9	75 5
" 2 P. M	57·7	56·3	57·1
" 9 P. M	71 9	72·8	72 0
" for the year	68·4	68·0	68·2
Clouds—Number of clear days*.	108·	122·	109·
" cloudy days.	257·	243·	256·
Means of sky covered at 7 A. M	62·9 per ct	56 9 per ct	60·1 per ct
" " " 2 P. M	61 9	59·8	60·9
" " " 9 P. M	48·6	47·5	46·1
" " for the year	57·8	54·7	55·7
Rain and melted snow—Amount—inches	62·935	43·573	46·925
No. of days on which rain or snow fell	134·	116·	127·
Prevailing Winds—Times in 1000.	N71°34′W·152	N88°15′W315	N75°12′W·198

*Sky one-third or less covered at the hours of observation.

General Abstract of the Meteorological Observations made at Philadelphia during the Year 1867.

By PROF. JAMES A. KIRKPATRICK.

Lat. 39° 57½′ *N.* *Long.* 75° 11¼′ *W. from Greenwich.* ***Height of Bar. fount,*** 60 *feet above mean tide in the Delaware River.*

1867. MONTHS.	Thermometer. Maximum.	Minimum.	Range. Monthly	Range. Mean daily	Mean daily oscillation.	Means. 7 A. M.	2 P. M.	9 P. M.	Average.	Barometer. Highest.	Lowest.	Range. Monthly	Range. Mean daily	Means. 7 A. M.	2 P. M.	9 P. M.	Average.	Dew Point. Means. 7 A. M.	2 P. M.	9 P. M.	Average.
	°	°	°	°	°	°	°	°	°	Inch	Inch.	Inch.	Inch.	Inch	Inch.	Inch.	Inch.	°	°	°	°
January	42	9	33	5·03	10·61	23·29	29·29	26·23	26·27	30·445	29·337	1·106	·225	29·918	29·883	29·919	29·907	17·02	19·44	17·44	17·97
February	55	16½	38½	6·43	14·64	35·84	43·36	40·66	39·95	30·970	29·303	1·667	·279	30·087	30·053	30·065	30·068	29·15	29·56	32·30	30·34
March	61½	20	41½	5·13	12·64	34·14	41·29	37·32	37·58	30·485	29·430	1·055	·235	30·032	30·002	30·0·5	30·016	27·17	27·36	28·45	27·66
April	80	36	44	6·54	17·75	47·22	59·92	52·32	53·15	30·314	29·295	1·019	·234	29·966	29·905	29·931	29·934	34·75	35·34	37·85	35·91
May	87	36	51	5·30	17·64	54·10	64·92	56·50	58·53	30·423	28·778	1·645	·214	29·855	29·80·4	29·836	29·832	44·31	43·44	45·39	44·38
June	88	48	40	4·39	17·07	67·60	77·17	69·67	71·48	30·309	29·474	·835	·105	30·006	29·986	29·994	29·995	59·28	59·01	60·15	59·48
July	91	58	33	3·99	14·69	72·00	81·27	75·00	76·09	30·249	29·665	·584	·097	29·941	29·912	29·916	29·923	60·96	60·16	63·88	61·67
August	86	59	27	3·68	12·44	71·02	78·18	74·56	74·59	30·210	29·578	·632	·108	29·967	29·939	29·944	29·950	63·93	63·96	66·01	64·63
September	86	43	43	5·36	14·52	63·12	73·62	66·80	67·84	30·466	29·623	·843	·136	30·084	30·50	30·058	30·064	56·82	59·05	59·18	58·35
October	80	38	42	5·28	15·39	50·71	63·55	55·79	56·68	30·465	29·556	·909	·175	30·053	30·045	30·0·0	30·026	45·02	46·43	48·06	46·50
November	69	24	45	6·37	14·47	42·95	51·31	40·68	46·98	30·342	29·250	1·092	·182	30·006	29·972	29·994	29·991	37·18	38·68	39·34	38·40
December	52½	8	44½	6·16	11·84	29·26	34·13	31·77	31·72	30·558	29·548	1·010	·256	30·038	30·027	30·032	30·032	23·34	23·35	25·42	24·03
Annual Means	91	8	83	5·30	14·48	49·27	58·17	52·78	53·41	30·970	28·778	2·192	·187	29·996	29·962	29·977	29·978	41·58	42·15	43·60	42·44
Winter	61	6	55	6·10	12·45	30·27	36·61	33·69	33·52	30·970	29·303	1·667	·240	29·985	29·948	29·973	29·969	24·04	24·99	25·80	24·94
Spring	87	20	67	5·62	16·01	45·15	55·38	48·71	49·75	30·485	28·778	1·707	·228	29·951	29·904	29·925	29·927	35·41	35·38	37·16	35·98
Summer	91	48	43	4·02	14·73	70·21	78·87	73·08	74·05	30·309	29·474	·835	·103	29·971	29·946	29·951	29·956	61··9	61·04	63·35	61·93
Autumn	86	24	62	5·67	14·79	52·25	62·83	56·42	57·17	30·466	29·250	1·216	·164	30·048	30·009	30·024	30·027	46·34	48·05	48·86	47·75
Means for 16 years	101	—9	110	5·53	14·77	49·94	59·82	53·31	54·36	30·970	28·778	2·192	·157	29·885	29·844	29·871	29·866	.....	43·9	.....	.....